GSFC S-480-31C

# GSFC SPECIFICATION

# TIROS

# SOLAR BACKSCATTER ULTRAVIOLET SPECTRAL RADIOMETER MOD 2

# (SBUV/2)

## FOLLOW-ON PROCUREMENT

MAY 1987

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

# GSFC SPECIFICATION

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# SOLAR BACKSCATTER ULTRAVIOLET

# SPECTRAL RADIOMETER MOD 2

# (SBUV/2)

## FOLLOW-ON PROCUREMENT

| | | |
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REVISION RECORD
NAS5-30355 ATTACHMENT B GSFC-S-480-31C, GSFC SPECIFICATION TIROS SOLAR BACKSCATTER ULTRAVIOLET SPECTRAL RADIOMETER MOD 2 FOLLOW-ON PROCUREMENT

| MOD NO. | DATE | CCR NO. | DATE | SECTION |
|---|---|---|---|---|
| 2 | 11/02/88 | | | TOC, 2., 2.1, 7.4.1.3 |
| 8 | 10/04/89 | 942 | 08/04/89 | 2., 2.3 |
| 9 | 01/03/90 | 909B | 12/06/88 | 6.2.7, 6.4.2, 7.3.2, |
| 14 | 10/22/90 | 942 | 08/04/89 | 2., 2.3 |
| 14 | 10/22/90 | 944 | 09/13/89 | 6.4.2.5 |
| 14 | 10/22/90 | 958A | 01/08/90 | Fig. 6.4, Table 6.2, 6.4.2.2, 6.4.2.5 |
| 14 | 10/22/90 | 949 | 01/05/90 | TOC, 6.2.2, 6.2.3, 6.2.4, 6.2.6, Fig. 6.1, Fig. 6.2, Fig. 6.3 |
| 14 | 10/22/90 | 1006 | 05/04/90 | 4.6.6.1, 4.7.2, 4.7.4.1, 4.7.5.3, 4.7.6, 8.3.1.2, 8.4.1, Table 4.9, Table 9.1, Table 9.2 |
| 20 | 09/09/91 | 1038 | 02/26/91 | 2.3 |
| 54 | 08/03/95 | 1290 | 03/09/95 | 4.5.3.2, Table 4.7, Table 9.3 |

REVISION RECORD
NAS5-30355 ATTACHMENT B GSFC-S-480-31C, GSFC SPECIFICATION TIROS SOLAR BACKSCATTER ULTRAVIOLET SPECTRAL RADIOMETER MOD 2 FOLLOW-ON PROCUREMENT

| MOD NO. | DATE | CCR NO. | DATE | SECTION |
|---|---|---|---|---|
| 54 | 08/03/95 | 1291 | 03/09/95 | Table 4.7, Table 9.3 |
| 55 | 12/12/95 | | | ALL REV C |
| 56 | 01/22/96 | 1368 | 10/27/95 | 4.1.3.1, 4.1.3.1.1, 4.1.3.1.2, 4.5.1, 4.5.3.2, 4.5.5.5, Glossary, Table 4.7, Table 9.3 |
| 60 | 01/22/96 | 1338 | 11/01/95 | 4.5.3.2, 4.5.5.5, Table 4.7, |
| 80 | 3/6/98 | 1500A | 2/24/98 | 4.2.3, 4.4.3.4 |
| 81 | 3/27/98 | 1452 | 7/1/97 | Appendix A |
| 81 | 3/27/98 | 1483 | 7/10/97 | Appendix A |
| 89 | 1/21/99 | 1559 | 7/02/98 | Table 4.9 |
| 89 | 1/21/99 | 1560 | 7/10/98 | 4.6.1.1 |
| 96 | 4/24/00 | 1711 | 3/31/00 | 4.3.2.1, 4.3.3.2 |
| 100 | 07/13/00 | 1611 | 5/07/99 | Appendix A |
| 102 | 08/30/00 | 1744 | 8/07/00 | 3.1 |
| 103 | 10/05/00 | 1750 | 8/22/00 | 5.1, 5.2.1, 5.2.2 (2,4,5, 7,8,9), 5.3.1, 5.5.2, 6.1.6, 6.1.7, 6.4.2.8, 6.5.1, 6.5.2, |
| 108 | 11/16/01 | 1764 | 9/29/00 | A-4 |
| 108 | 11/16/01 | 1765 | 9/29/00 | A-4 |
| 108 | 11/16/01 | 1831 | 6/21/01 | A-4 |
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## APPENDICES

# 1. SCOPE

This specification describes, specifies the performance of, and defines the testing and calibration of, a Solar Backscatter Ultraviolet Spectral Radiometer (SBUV/2) for the ATN series of NOAA polar orbiting spacecraft.

The SBUV/2 shall be a non-spatial scanning, nadir viewing instrument designed to measure scene radiance in the spectral range from 160 nanometers (nm) to 400nm to permit the calculation of the vertical distribution of ozone in the Earth's atmosphere, to measure the total ozone in the atmosphere, to monitor the solar spectral irradiance, and to monitor the Earth's albedo.

The SBUV/2 shall consist of an optical system having a field of view of 11.33 degrees, square, that can monitor the ozone component of the upper atmosphere by making radiometric measurements in twelve discrete spectral bands corresponding to the ozone absorption bands. The solar spectral irradiance shall be measured directly by inserting, upon command, a diffusing mechanism between the instrument entrance aperture and the Sun. In this mode measurements shall be made in nominally equal spectral increments, not to exceed 0.2nm while the instrument scans spectrally from 160nm to 400nm. The albedo of the Earth can be measured by stowing the diffusing mechanism and operating the instrument in the same mode.

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## 2. APPLICABLE DOCUMENTS (Mod 2, Mod 8, Mod 14)

The issues of the following documents in effect on the issue date of this specification or as otherwise shown, shall apply to the fabrication and design effort conducted in accordance with this specification, and shall be considered part of this specification. In the event of conflict between this specification and any referenced document, with the exception of the UIIS (Ref. 2.3(2)), this specification shall govern.

### 2.1. GSFC AND GENERAL GOVERNMENT SPECIFICATIONS AND STANDARDS (Mod 2, Mod 14)

(1) Federal Standard 209B: Clean Room and Work Station Requirements, Controlled Environment.

(2) NHB 5610.1: Handbook for Preparation of Work Breakdown Structures.

(3) GSFC S-250-P-1C: Contractor Prepared Monthly, Periodic, and Final Reports.

(4) GSFC-X-600-87-11: Metsat Charged Particle Environment Study, (Revised Edition) Method 2, E.G. Stassinopoulos, J. M. Barth and R. L. Smith, August 1987.

(5) NASA Ref. Publication 1014: An Outgassing Data Compilation of Spacecraft Materials, January 1978.

(6) Letter to Tiros Project from Material Control and Applications Branch; Contamination Cover for the Earth Radiation Budget Satellite System (ERBSS) and the Solar Backscatter Ultraviolet (SBUV) Radiometer Instruments, dated March 2, 1979.

(7) The Prevention of Electrical Breakdown in Spacecraft-NASA SP 208.

(8) Deleted

## 2.2. MILITARY SPECIFICATIONS AND STANDARDS

(1) MIL-STD-130D: Identification Marking for U.S. Government Property

(2) MIL-STD-480: Configuration Control, Engineering Changes, Deviation and Waivers.

(3) MIL-D-1000: Military Specification Drawings, Engineering and Associated Lists, for Categories, A, B, C, D, G, H, Using Form 2 Drawings.

## 2.3. GE SPECIFICATIONS (Mod 14, Mod 20)

(1) IS-2280259: Tiros-N General Instrument Interface Specification, Rev. AD (Effective Tiros-N, NOAA A-J S/C).

(2) IS-2295548: Tiros-N Unique Instrument Interface Specification for the SBUV/2 Radiometer; Rev. AE.

(3) IS-3267415: Tiros-KLM General Instrument Interface Specification (Effective NOAA KLM S/C).

## 2.4. GE GENERAL REPORTS

(1) Advanced Tiros-N Payload Growth Study, Final Report, March 21, 1978.

(2) Advanced Tiros-N SBUV/ERBE Interface Definition Study Final Documentation, September 22, 1978, and December 20, 1978.

## 2.5. GENERAL REFERENCE DOCUMENTS

(1) Self-Study Manual on Optical Radiation Measurements Part 1 -- Concepts:

NBS Technical Note 910-1 (Chapters 1 to 3), March 1976
NBS Technical Note 910-2 (Chapters 4 & 5), February 1978
NBS Technical Note 910-3 (Chapter 6), June 1977
NBS Technical Note 910-4 (Chapters 7 to 9), June 1979

# 3. GOVERNMENT FURNISHED EQUIPMENT (GFE) AND DEFINITIONS

## 3.1. GFE (Mod 102)

The following items will be furnished to the instrument contractor to aid in his performance of the contractual effort.

(1) All residual parts, components, spares, and subassemblies procured or developed under contracts NAS5-26400 and NAS5-29230.

(2) All residual test equipment, UV sources, and test fixturing developed or procured under contracts NAS5-26400 and NAS5-29230.

(3) SBUV Diffusers will be calibrated by GSFC. Replacement FEL and D2 lamps will be provided as required.

(4) Deleted

(5) Sensor Module and Electronics and Logic Module (SM/ELM) interconnect cables, built to flight drawings by the spacecraft contractor, for instrument acceptance test and calibration.

Note: Ball shall be responsible for all recalibration services of sources, and source control consoles. All lamp calibrations will be traceable to the National Institute of Standards and Technology (NIST) and the Diffusers will be traceable to NIST via GSFC's calibration Laboratory.

## 3.2. DEFINITIONS

### 3.2.1. Measurement Precision

In this specification the use of the term "measurement precision" is defined as the standard deviation of a statistically meaningful number of samples of that measurement.

### 3.2.2. Repeatability

In this specification the use of the term "repeatability" is defined as the allowable difference between successive measurements of the same parameter, or successive occurrence of the same event.

### 3.2.3. Accuracy

In this specification the use of the term "accuracy" or "measurement accuracy" is defined as the error (estimated uncertainty) in the measurement. This estimate shall include both systematic and random errors.

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# 4. TECHNICAL REQUIREMENTS

## 4.1. FUNCTIONAL REQUIREMENTS

### 4.1.1. General

The SBUV/2 shall be a non-spatial scanning, spectrally scanning instrument designed to measure scene radiance and solar spectral irradiance in the spectral range from 160nm to 400nm to permit the calculation of total ozone in the Earth's atmosphere. The instrument shall operate in five distinct modes. In the first mode, called the Discrete Mode, the instrument shall sequentially measure the scene radiance and the solar spectral irradiance in 12 discrete spectral bands. In the second mode, called the Sweep Mode, the spectral bandpass will sweep from 160nm to 400nm in a continuous manner (this may be a rapid series of small, discrete steps). In this mode, radiometric measurements will be made by electronic sampling of the output signal, while the grating moves. Each measurement shall have an equal integration time sufficient to yield a sequence of a minimum of 1000 measurements, each corresponding to a nominally equal change in the spectral bandpass. Either the scene spectral radiance or solar spectral irradiance is measured in this mode. In the latter case the diffuser must be deployed. In the third mode, called the Wavelength Calibration Mode, the instrument operates as in the Discrete Mode, but stops at "n" pre-selected wavelength positions corresponding to the on-board calibration lamp. In the fourth mode, called the Monochromator Stop Mode, the spectral scan mechanism will stop in its present position upon receipt of the stop command. In the fifth mode, called the Monochromator Caged Mode, the instrument will lock the spectral scan mechanism in a predetermined position. This mode is for use during the launch phase of the flight.

The radiometer shall consist of an optical system, detectors, associated electronics, spectral scan system, diffusing mechanism, and an on-board wavelength and electronic calibration system. Most system components will be housed in one package called the Sensor Module (SM) that will be mounted on the external surface of the Equipment Support Module (ESM) of the spacecraft. Most of the electronics will be separately housed in the Electronics and Logic Module (ELM) which will be mounted internally to the ESM.

### 4.1.2. Optical System

The SBUV/2 shall have a field of view (FOV) of 11.33 degrees, $\pm$0.57 degree, square, in both the Discrete and Sweep Modes. The spectral step of the monochromator shall be no greater than 0.1nm. In the Discrete Mode the monochromator shall step and dwell at 12 specific wavelength positions and the complete cycle for step, dwell and retrace shall not exceed 32 seconds. In the Sweep Mode the monochromator shall step continuously at a uniform rate from 160nm to 400nm, and the total cycle including retrace shall be completed within 256 seconds.

### 4.1.3. In-flight Calibration

The SBUV/2 must provide a method of periodically calibrating the radiometer while in orbit. This shall include wavelength, detector gain and electronics calibration. The in-flight calibration sequence will be initiated by a combination of command and automatic sequence.

#### 4.1.3.1 Diffuser (Mod 56)

##### 4.1.3.1.1 Diffuser Operational Requirements (Mod 56)

The instrument shall be equipped with a deployable diffuser capable of providing:

1) an unobstructed view of the Earth;

2) illumination of the instrument entrance aperture with the on board calibration lamp radiation;

3) illumination of the instrument entrance aperture with solar radiation;

4) a decontamination position

The diffuser angle for the solar position will be 28 degrees for Flight Models 5 and 6, and 37 degrees for Flight Model 7 from the reference.

##### 4.1.3.1.2 Diffuser Characterization (Mod 56)

The instrument shall provide for monitoring changes in the relative spectral reflectivity of the diffuser, over the spectral range 185 to 405nm.

### 4.1.4. Spacecraft Interface

#### 4.1.4.1. Power

The spacecraft shall provide regulated power at +28 volts, and +10 volts, as defined in the UIIS and GIIS, the latter being used normally to power CMOS to CMOS interface circuits.

#### 4.1.4.2. Logic Interface

The SBUV/2 shall interface with the Tiros Information Processor (TIP) from which it will receive all clock signals, synchronization pulses, and data enable pulses.

## 4.2. OPERATIONAL REQUIREMENTS

### 4.2.1. Nominal Orbital Parameters

Orbit Altitude - 833km + 18.5km or 870km + 18.5km

Orbital Period - 102 minutes

Longitude Shift - 25.6 degrees/orbit

Orbit Inclination - 99 degrees

Longitude of Orbit Nodes (equitorial crossing) - 1240 to 1520 ascending, local mean time.

Gamma Angle (angle between the orbit normal and the solar vector) - 40 to 80 degrees.

### 4.2.2. Operational Modes

The following operational modes are defined for the SBUV/2:

* Launch Phase and Orbital Acquisition Mode: Instrument status will be defined for this flight phase.
* Mission Mode: Normal operating mode of the instrument.
* Activation Mode: Initial turn on and warm up of the instrument.
* Standby Mode: Minimum power mode for survival; this is a planned shutdown.
* Safe State Mode: Emergency off mode; this is a spacecraft emergency and the intent is that all instruments will be reactivated upon spacecraft recovery.

### 4.2.3. Life Requirements

The SBUV/2 shall be designed to operate continuously within specification for two years in orbit and three months of operating time at the spacecraft contractor's facility following a maximum period of five years in storage. All mechanisms have sufficient design margin that changes in friction during the operating lifetime of the instrument will not affect performance. All age sensitive parts, materials, and components relative to the 5 year storage period, shall be identified in writing and the information submitted to the Technical Officer.

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## 4.3. OPTICAL REQUIREMENTS

### 4.3.1. General

The SBUV/2 optical system shall consist of an optics assembly, detector assemblies, and other mechanism(s) required by the system design. The system shall also contain a separate radiometric channel having an optical axis coincident with or parallel to that of the monochromator. This radiometric channel, hereinafter referred to as the Cloud Cover Radiometer (CCR), must utilize an independent method for bandpass selection.

### 4.3.2. Instantaneous Field of View (IFOV)

The SBUV/2 shall have a half-power IFOV whose size is 11.33 ± 0.57 degrees, for all spectral bands in the Discrete Mode and the CCR. In addition, the half-power IFOV shall be square to within 0.1 degree; and each channel of the Discrete Mode shall have an IFOV that does not differ from the CCR IF0V by more than 0.1 degree in each of two perpendicular directions.

#### 4.3.2.1. Field Uniformity

The relative response, as measured by two mutually perpendicular scans of a point or narrow slit source across the IFOV (one scan perpendicular to and one scan parallel to the entrance slit) shall not vary by more than ± 20 percent from the mean, within an angular interval, centered in the IFOV, whose width is 80 percent of the half-power IFOV. The width of the point or narrow slit source shall not exceed 15 percent of the required IFOV. In the case of the CCR the variation within the 80 percent of half-power IFOV shall not exceed ± 5 percent.

Compliance with this requirement will be demonstrated by showing that the specification is met in each spectral band of the Discrete Mode and by the CCR.

#### 4.3.2.2. Out of Field Response

The total system response obtained while the instrument (masked to exclude a central FOV having an angular dimension 10 percent larger than the measured half-power IFOV) views a large, uniform, diffuse source subtending an angle at the entrance aperture 10 times the half-power IFOV and whose intensity does not exceed the maximum expected scene radiance, shall not exceed 1 percent of the total system response obtained while the instrument views the same source with the mask removed, at any spectral position within the range 250nm to 400nm. In addition, any strong, localized beam of UV energy impinging on the diffuse plate at any position outside the masked out area, with the mask in place, shall not exceed the observed system noise. An alternate method of demonstrating instrument conformance with this requirement is permissible.

#### 4.3.3. Optical Alignment

##### 4.3.3.1. Precision

All alignment measurements shall be made with a precision of 0.01 degree or better.

##### 4.3.3.2. Alignment Requirements

The effective optical axis of the monochromator and of the CCR shall be aligned parallel to within 0.1 degree. The effective optical axis is defined as follows:

FM-1 to -7, the direction determined by bisecting the angle between the half-power response points determined from two mutually perpendicular FOV scans. This requirement shall hold between each spectral band in the Discrete Mode and (1) the CCR, and (2) the instrument reference.

FM-8, the direction determined by the angle-weighted method based on interpolating the test points determined from two mutually perpendicular FOV scans.** This requirement shall hold between [channel 12] in the Discrete Mode and the CCR.

The alignment of the optical axis of the monochromator to the instrument reference shall be 0.1 degree or less, and the alignment of the instrument reference axis to the spacecraft +X axis (nadir) shall be 0.1 degree or less.

** NOTE:
The alignment of the effective optical axis of the monochromator and the CCR is defined by comparison of the effective centers of the IFOV of channel 12 and the CCR as determined by the angle-weighted method below. The effective center of each channel is calculated from the following formula:

$$\Delta\Omega = \sum Y_i \theta_i (\Delta\theta_i) / \sum Y_i (\Delta\theta_i)$$

Where $\Delta\Omega$ is the pointing error with angle-weighted response;
$Y_i$ is the response interpolated at point (i);
$\theta_i$ is the angle position of point (i);
$(\Delta\theta_i)$ is the angle spacing for point (i);
$\sum$ is done over -8.0° to +8.0° with 0.1° spacing, for total of 161 points.

##### 4.3.3.3. Alignment Changes

The alignment of the instrument optical axis with respect to the instrument references and to the instrument mounting surface shall not change by more than 0.05 degrees as a result of any qualification level testing, launch, and in-orbit operation, and the relative alignment of all bands of the Discrete Mode, the CCR, and the instrument reference shall remain within specification.

### 4.3.4. Spectral Bandpass Requirements

The bandpass requirements are given in Table 4.1.

#### 4.3.4.1. Out-of-Band Response

The total out-of-band response, integrated over all wavelengths outside a spectral region thrice the measured bandwidth, but centered on the central wavelength ($\lambda$ o), shall not be greater than 1 percent of the response within the total measured bandpass, for all spectral bands between 250nm and 400nm. Said another way: If $N_\lambda$ is the scene radiance and $S_\lambda$ is the instrument transfer function and $\Delta\lambda$ is the measured half-power bandwidth, then:

TABLE 4.1

SBUV/2 SPECTRAL BANDPASS REQUIREMENTS

| Central Wavelength (nm) | Bandwidth (nm) |
|---|---|
| **Discrete Mode** | |
| 339.89 ± 0.05 | 1.0 + 0.2 - 0 |
| 331.26 ± 0.05 | " |
| 317.56 ± 0.05 | " |
| 312.57 ± 0.05 | " |
| 305.87 ± 0.05 | " |
| 301.97 ± 0.05 | " |
| 297.59 ± 0.05 | " |
| 292.29 ± 0.05 | " |
| 287.70 ± 0.05 | " |
| 283.10 ± 0.05 | " |
| 273.61 ± 0.05 | " |
| 252.00 ± 0.05 | " |
| Sweep Mode | |
| 160 - 400 ± 0.25 | 1.0 + 0.2 - 0 |
| **Cloud Cover Radiometer** | |
| 379 ± 1.0 | 3.0 ± 0.3 |

$$\frac{\displaystyle\int_{-\infty}^{\lambda_0 - \frac{3\Delta\lambda}{2}} S_\lambda N_\lambda \, d\lambda + \int_{\lambda_0 + \frac{3\Delta\lambda}{2}}^{\infty} S_\lambda N_\lambda \, d\lambda}{\displaystyle\int_{\lambda_0 - \Delta\lambda}^{\lambda_0 + \Delta\lambda} S_\lambda N_\lambda \, d\lambda} \leq 0.01$$

To demonstrate compliance with this specification the total out-of-band response shall be determined for each band of the Discrete Mode and for the CCR. The source used shall simulate as close as possible the The SBUV/2 monochromator shall have a spectral resolution capability of 0.2nm, for the entire slit height, over the spectral range 250nm to 400nm. This can be demonstrated by measurement at 253.7nm and extended by ray trace analysis to the balance of the spectral range.

4.3.5. Polarization Sensitivity

The sensitivity of the SBUV/2 to linear polarization of the scene, as given by the equation below, shall be no greater than 0.05, for all wavelengths in the range 252.0nm to 339.8nm.

$$Ps = \frac{I_{max} - I_{min}}{I_{max} + I_{min}} \leq 0.05$$

where $\psi$ max is the maximum response of the SBUV/2 to a 100 percent linear polarized source, and $\psi$ min is the minimum response of the SBUV/2 to a 100 percent linear polarized source of the same intensity. The polarization operator of the test equipment used in the measurement of the polarization sensitivity must be independently determined and analytically removed from the system test results.

### 4.3.6. Wavelength Determination

The optical design shall include means for measuring the wavelength position of the SBUV/2 and for subsequent calibration of the indicated wavelength in orbit. One method for effecting in orbit wavelength calibration is to fly a stable source whose emission lines are accurately known. In addition, this source will be utilized to measure relative spectral reflectance changes, both on the ground and in orbit, and shall serve as a stimulus for prelaunch spacecraft level aliveness testing.

### 4.3.7. Stray Light Rejection from the Near Field

The instrument shall be baffled to prevent stray light from any portion of the spacecraft or other subsystem from entering the entrance aperture from sources outside the clear FOV as specified in the Unique Instrument Interface Specification, IS-2295548 (UIIS) The instrument response to any stray light striking the instrument on any surface (except the entrance aperture and within the instrument FOV) from any angle shall be less than one percent of the total response for a minimum value of scene radiance whose integrated response over any spectral band is 1000 counts or greater. The source or sources used to irradiate the instrument for compliance testing shall have an intensity and view-factor of sufficient size to yield irradiance levels at any surface equal to maximum solar irradiance for any spectral interval within the range 250nm to 400nm.

## 4.4. SYSTEM PERFORMANCE REQUIREMENTS

### 4.4.1. General

The SBUV/2 shall be designed to meet the performance requirements as given in this section.

### 4.4.2. Dynamic Range

The SBUV/2 shall be capable of measuring scene radiance over the dynamic range given in Table 4.2 for each operating mode. This table also contains the minimum and maximum solar irradiance values. Table 4.3 lists the expected orbital radiance extrema for the discrete wavelengths and for the CCR.

#### 4.4.2.1. System Linearity

The nonlinearity of system response shall not exceed 1 percent of the output signal over the total dynamic range. In other words, if the system response to a scene radiance of 'No' is 'Ro', then system response to a scene radiance of 'nNo' must be nRo $\pm$ 0.01 (nRo-Ro); where 1) 'n' is any nonzero, positive number, 2) 'No' and 'nNo' must lie within the required or expected dynamic range of the channel (extrema included), and 3) system response shall be the mean of a minimum of 50 samples. In addition, system response shall be independent of instrument orientation in the Earth's magnetic field. Compliance with these requirements shall be demonstrated by measurement in air only.

#### 4.4.2.2. Minimum Quantizing Resolution

The number of quantization levels shall be related to the system as follows: Quantization noise shall not contribute to instrument noise by more than one percent. Instrument noise in this context is defined as the RSS value of all independent noise sources from the detector through the input of the analog to digital converter. This requirement can be restated as follows: If $E_n$ is the input noise voltage to the analog to digital converter at minimum scene radiance input signal, then, the digitization interval $E_o$ must be no greater than $0.5E_n$. On the other hand, it need be no smaller either.

TABLE 4.2

SBUV/2 DYNAMIC RANGE REQUIREMENTS

| | Discrete Mode | Sweep Mode | Cloud Cover Radiometer |
|---|---|---|---|
| Maximum Scene Radiance (mW/M$^2$-sr-Å) | 40 (339.8nm) | 53 (400nm) | 40 |
| Minimum Scene Radiance (mW/M$^2$-sr-Å) | 1.2x10$^{-4}$* | 1.2x10$^{-4}$* | 0.125 |
| Maximum Solar Irradiance (mW/M$^2$-Å) | 120 (339.8nm) | 166 (400nm) | N/A |
| Minimum Solar Irradiance (mW/M$^2$-Å) | 3 (252.0nm) | 0.01 (160 nm) | N/A |

TABLE 4.3

NOMINAL ATMOSPHERIC SPECTRAL RADIANCE

| Wavelength (nm) | $N_8$, Max (mW/M$^2$-sr-Å) | $N_8$, Min (mW/M$^2$-sr-Å) |
|---|---|---|
| 252.0 | 2.00x10$^{-3}$ | 1.2x10$^{-4}$ |
| 255.5 | 4.07x " | 2.72x" |
| 273.5 | 8.94x " | 4.98x" |
| 283.0 | 1.89x10$^{-2}$ | 9.78x" |
| 287.6 | 2.35x " | 1.30x10$^{-3}$ |
| 292.2 | 4.96x " | 2.39x" |
| 297.5 | 9.03x " | 3.48x" |
| 301.9 | 0.34 | 3.84x" |
| 305.8 | 1.42 | 6.72x" |
| 312.5 | 10.22 | 1.49x10$^{-2}$ |
| 317.5 | 16.39 | 3.09x" |
| 331.2 | 27.02 | 2.08x10$^{-1}$ |
| 339.8 | 28.09 | 4.12x" |
| 380.0 | 45.52 | 2.52x" |

---

Table 4.2: (xxxx) gives wavelength for which radiance/irradiance values are applicable.

* at 252.0nm

## TABLE 4.4

## SBUV/2 MINIMUM SIGNAL TO NOISE

| Central Wavelength (nm) | Required S/N (Note 1) | | Source Intensity |
|---|---|---|---|
| | RADIANCE MEASUREMENTS | | RADIANCE |
| | Discrete Mode | Sweep Mode (Note 4) | (mW/M$^2$-sr-Å) |
| 252.00 | 35 | 10 | (Note 2) |
| 273.61 | 100 | 30 | $4.98x10^{-4}$ |
| 283.10 | 200 | 60 | 9.78x " |
| 287.70 | 260 | 80 | $l.30xl0^{-3}$ |
| 292.29 | 400 | 145 | 2.39x " |
| 297.59 | 400 | 210 | 3.48x " |
| 30l.97 | 400 | 230 | 3.84x " |
| 305.87 | 400 | 400 | 6.72x " |
| 312.57 | 400 | 400 | $1.49x10^{-2}$ |
| 317.56 | 400 | 400 | 3.09x " |
| 331.26 | 400 | 400 | $2.08x10^{-1}$ |
| 339.89 | 400 | 400 | 4.12x " |
| CCR | 100 | --- | (Note 3) |
| | IRRADIANCE MEASUREMENTS | | IRRADIANCE |
| | | | (W/cm$^3$) |
| 160 | --- | 2.0 | 0.26 |
| 170 | --- | 50 | 0.30 |
| 180 | --- | 250 | 0.80 |
| 190 | --- | 400 | 1.60 |
| 200 | --- | 400 | 3.40 |

(Notes-next page)

Notes: 1. Except for data pertinent to Notes 2, and 3 the required S/N values are not true signal to noise ratios. These values are to be defined as peak signal divided by background noise (rms).

2. To be measured while viewing a uniform target whose radiance is

$1.20\text{x}10^{-4}$ mW/M$^2$-sr-Å, averaged between 251.0nm and 253.0nm.

3. To be measured while viewing a uniform target whose radiance is

0.125 mW/M$^2$-sr-Å, averaged between 375nm and 385nm.

4. In the sweep mode at the cross over between gain ranges 1 and 2, the maximum required S/N shall not exceed 100 at any specified wavelengths above 292 nm.

### 4.4.3. Radiometric Accuracy

#### 4.4.3.1. Signal to Noise Requirements

The SBUV/2 shall be designed to meet the required signal to noise ratio as specified in Table 4.4.

#### 4.4.3.2. Absolute Radiometric Accuracy

The quartz-iodide, argon arc or other standard sources of spectral irradiance used for preflight calibration shall be the best sources that can be provided by the National Bureau of Standards. The absolute accuracy requirements for the instrument are given in Table 4.5.

TABLE 4.5

ABSOLUTE RADIOMETRIC ACCURACY REQUIREMENTS

(1) Spectral Irradiance Calibration (Instrument Diffuser)

| WAVELENGTH (NM) | SOURCE | MAX PERCENT ERROR OF SOURCE | SOURCE* TRANSFER | DIFFUSER (GONIO-METRIC) | OTHER ERROR | MAX. ABSOLUTE ERROR OF MEASUREMENT (RSS) |
|---|---|---|---|---|---|---|
| 200-250 | Mini-Arc | 6.0 | 3.5 | | 1.0 | 7.02 |
| 250 | QI | 2.6 | 2.0 | | 1.0 | 3.43 |
| 300 | QI | 2.1 | 2.0 | | 1.0 | 3.07 |
| 350 | QI | 1.7 | 2.0 | | 1.0 | 2.81 |
| 400 | QI | 1.5 | 2.0 | | 1.0 | 2.69 |

(2) Spectral Radiance Calibration (Test Diffuser)

| WAVELENGTH (NM) | SOURCE | MAX PERCENT ERROR OF SOURCE | SOURCE* TRANSFER | DIFFUSER (GONIO-METRIC) | OTHER ERROR | MAX. ABSOLUTE ERROR OF MEASUREMENT (RSS) |
|---|---|---|---|---|---|---|
| 200-250 | Mini-Arc | 6.0 | 3.5 | 2.0 | 1.0 | 7.30 |
| 250 | QI | 2.6 | 2.0 | 1.0 | 1.0 | 3.57 |
| 300 | QI | 2.1 | 2.0 | 1.0 | 1.0 | 3.23 |
| 350 | QI | 1.7 | 2.0 | 1.0 | 1.0 | 2.98 |
| 400 | QI | 1.5 | 2.0 | 1.0 | 1.0 | 2.87 |

(3) Ratio of Radiance to Irradiance Accuracy

The ratio of the radiance calibration to irradiance calibration, at the same wavelength, shall be determined to an accuracy of 2.35 percent in the spectral range 200nm-250nm and to an accuracy of 1.53 percent at 250nm, 1.57 percent at 300nm and 1.82 percent in the spectral range 340nm-400nm. The ratio is to be determined from radiance and irradiance measurements made with a minimum time separation. During the time of ratio measurement, the instrument response shall not vary by more than 0.5 percent.

* Includes non-goniometric diffuser errors.

#### 4.4.3.3. Radiometric Stability and Repeatability

##### 4.4.3.3.1. Short Term Stability

The radiometric response of the instrument shall meet the following stability requirements. The corrected mean response of the instrument shall not differ by more than l percent from a previous or subsequent response measurement made while viewing the same source operating at equal intensity, but separated in time by at least 24 hours, for each wavelength in the Discrete Mode. The mean response is to be determined from at least 50 successive data samples taken with the wavelength drive stopped at each Discrete Mode position. This instrument data is to be corrected for changes in instrument temperature and other response dependent parameters, if any, before comparisons are made.

##### 4.4.3.3.2. Long Term Stability

It is desired that the change in radiometric response, as defined in the previous paragraph, shall not change by more than 3 percent over a period of 6 months. Because of the impracticability of demonstrating compliance by actual measurement before instrument delivery, compliance can be demonstrated by an estimate of long term stability based on analysis. This analysis must use measured instrument rates of change as well as vendor supplied subsystem test data.

#### 4.4.3.4. System Noise Measurements

The standard deviation of 50 or more samples of radiometric data taken while viewing an external UV source, for any spectral band is, by definition, the rms system noise for that spectral band. The system noise shall not increase by more than 20% in the presence of a 0.07 pound mechanical vibration over a frequency range of 100 to 900 Hz over the operational temperature range.

#### 4.4.3.5. Wavelength Accuracy and Precision

All wavelength measurements for both the Discrete Mode and Sweep Mode shall be made with an absolute accuracy given by the tolerance on the defined wavelength in Table 4.1. The required measurement precision during ground calibration of SBUV/2 shall be $\pm$ 0.005nm or better.

#### 4.4.3.6. System Error Analysis

The contractor shall perform a complete error analysis on the system which, when correlated with measured data, will demonstrate that all accuracy and error requirements of this specification have been met.

The system includes the instrument plus all associated test equipment.

### 4.4.4. Instrument Calibration

#### 4.4.4.1. In-flight Measurement of Detector Gain

The SBUV/2 shall provide for in-flight measurement of changes in gain of the detector(s), including the preamplifier stage. The measurements shall be sensitive enough to determine a gain change of 0.5 percent or less in the spectral range 300nm to 340nm. Averaging of 100 measurements is permissible.

#### 4.4.4.2. In-flight Wavelength Calibration

The SBUV/2 shall provide the means for in-flight wavelength calibration. The onboard calibration shall be sensitive enough to detect a 0.1nm shift in the indicated wavelength, with a measurement precision of 0.01nm.

#### 4.4.4.3. Preflight Radiometric Calibration

The contractor shall provide a complete spectroradiometric calibration of the instrument from 160nm to 400nm over its entire dynamic range and for all applicable operating modes. This calibration shall demonstrate that the instrument has met all applicable performance requirements. Calibration details are given in section 6.5 of this specification.

#### 4.4.4.4. In-flight Diffuser Calibration

The contractor shall demonstrate by direct test that the system provided to monitor the diffuser performance is sensitive enough and has the stability required to detect a one percent change in the diffuser relative spectral reflectance in orbit, with a precision of 0.5 percent, over the spectral range 185nm to 405nm. This can be demonstrated on a test to test basis or by using averages of up to eight automated data sequences which approximates the monthly orbital data collection in this mode.

#### 4.4.5. Radiation Induced Noise Immunity

It is required that in-orbit signal contamination, due to high energy particle induced radiation noise shall be less than 1 percent of the signal due to actual scene radiance. In the tropics the typical scene radiance at 252nm is approximately $2X10^{-3}$ mW/$M^2$-sr-A. The contractor shall minimize noise susceptibility by identifying and shielding critical components to the extent allowed by the overall weight limitation. No special tests are required in this area.

#### 4.4.6. Radiometric DC Level

The radiometric data output shall include a measurement of the DC signal level which shall be sampled at the same rate as normal radiometric data.

## 4.5. ELECTRICAL REQUIREMENTS

### 4.5.1. General (Mod 56)

The SBUV/2 ELM, located inside the ESM, shall contain, as a minimum, the ELM power converter, TIP interface circuitry, clock generators, command interface circuitry, data mux and formatter and other data output circuitry, accumulator and integrator circuitry, chopper control circuitry, diffusing mechanism drivers and calibration lamp supply. The data format shall be controlled by the contents of an onboard memory system. The memory system for FM 5 and FM 6 shall consist of a Programmable Read Only Memory (PROM) and Random Access Memory (RAM) and associated support circuitry (called Fixed/Flex). For FM 7, the memory system shall consist of two RAMs (called $FLEX_1$ and $FLEX_2$) and support circuitry. All interconnection between the spacecraft and the SBUV/2 will be through the ELM. The remainder of the electronics shall be contained in the Sensor Module. This includes the remaining power supplies including any high voltage supplies, detectors and preamplifiers, encoders, wavelength drive and chopper motors, electronic calibration generator, and signal processing electronics.

### 4.5.2. Power System

#### 4.5.2.1. General

The SBUV/2 subsystem power supply shall provide all power needed to operate the system except as noted. The system will operate from the spacecraft +28 volt power system, which will be supplied to the instrument in the form of a +28 volt main bus, a switched +28 volt analog temperature telemetry bus and a +28 volt pulse load bus. The latter bus shall be used for powering stepper motors, heaters, and other high current pulse loads which cannot meet the main bus current ripple and transient load requirements. Those subsystems which are powered from the pulse load bus (PLB) need not be isolated by a DC/DC converter.

A +10 volt bus is available for powering CMOS to CMOS interface circuits. This "interface bus" uses standard circuits to power commands, clocks, synchronization pulses, digital data pulses and levels, and data transfer pulses. No DC/DC converter is required for use with these standard circuits.

Any DC/DC converter within the SBUV/2 shall be coherent with the spacecraft clock (at the same frequency or any subharmonic frequency of the spacecraft clock). In the event that more than one DC/DC converter is utilized, one shall be designated as the prime converter and synchronized to the spacecraft clock. The others will be synchronized to the prime converter to eliminate intra-instrument beat frequencies.

#### 4.5.2.2. SBUV/2 Operating Characteristics

##### 4.5.2.2.1. Normal Operation/Input Voltage Range

The instrument shall perform within

specification when operated from the main power bus even if the voltage on that bus should vary from +27.44 volts to +28.56 volts.

4.5.2.2.2. Over/Under Voltage Protection

The instrument shall withstand, without damage, the following continuous over voltage and under voltage conditions:

| | Max Volts | Min Volts |
|---|---|---|
| +28 Volt Main Bus | +38 V | +16 V |
| +28 Volt Analog Temperature Telemetry Bus | +38 V | +16 V |
| +28 Volt PLB | +38 V | +15 V |
| +10 Volt Interface Bus | +15 V | +9 V |

Under these conditions, components shall not be stressed beyond their specified maximum ratings (including the effects of environment). The instrument shall be operating within specification, and in synchronization with the TIP, within 3 minutes after the over/under voltage condition is removed. In practice the instrument will experience the extreme voltage excursions on the power busses as transients, and this will occur during spacecraft regulator switching only.

4.5.2.2.3. Additional Requirements

All additional requirements and other information regarding the spacecraft power system are given in the General Instrument Interface Specification (GIIS), IS-2280259.

4.5.2.2.4. Input Configuration

Two pins in parallel shall be used for both the regulated power input and return. One input and one return line shall be routed to the connector. The regulated power return line shall not be connected to the case (chassis) ground of the SBUV/2 and all input leads shall be isolated from the case by at least 10 megohms.

4.5.2.3. Fusing

There shall be no fuses internal to the unit. Fusing will be supplied by the spacecraft power system.

4.5.2.4. Power

The SBUV/2 total power drawn from the spacecraft shall be no greater than 17 watts orbital average in the full operating mode, and the instantaneous peak power shall not exceed 42 watts.

4.5.2.5. Input Filter

An input filter as shown in Figure 4.1 shall be connected to the +10 volt interface bus.

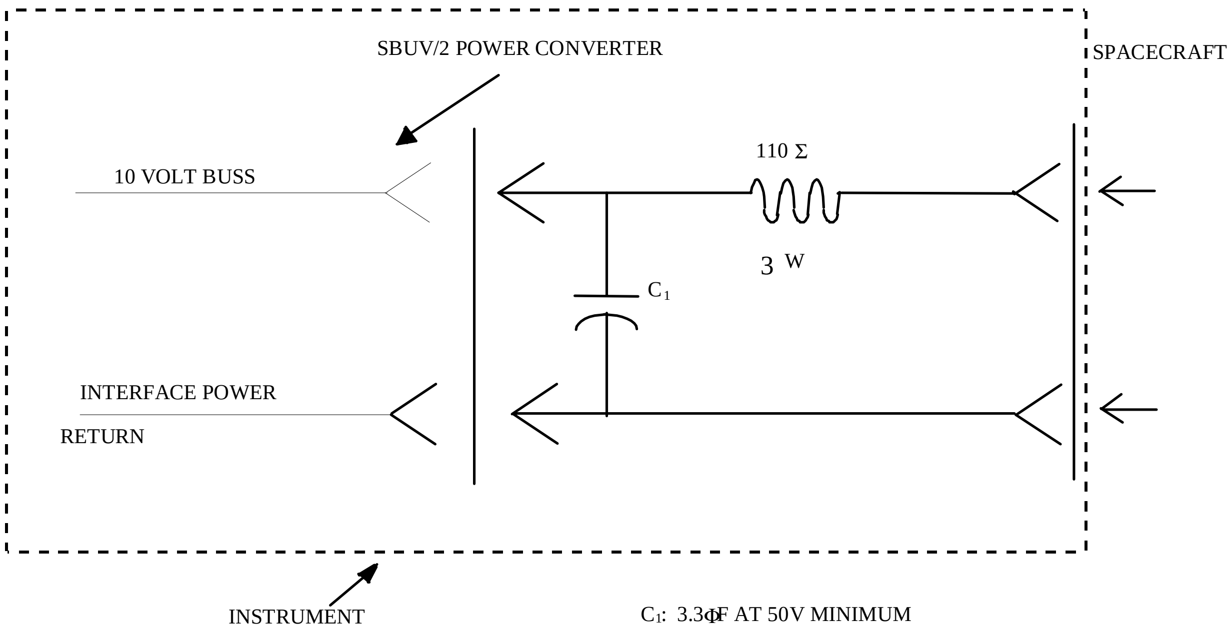


Figure 4.1 + 10 Volt Interface Bus Input Filter

#### 4.5.2.6. High Voltage Power Supplies

The output voltage of any high voltage detector power supply shall not exceed 3600 volts. Current limiting circuitry shall be provided as part of any high voltage power system design to prevent permanent damage due to arc-over should it occur during testing. The contractor shall follow the guidelines for high voltage design contained in reference 2.1(13) as well as the following general precautionary design criteria:

a) The design and layout of any high voltage power supply shall be conducive to complete encapsulation. Any component not encapsulated having an applied voltage of 100 volts or greater must be well vented.

b) The leak-down time constant in vacuum must be on the order of a few seconds.

c) No hollow core components or wax treated components shall be used.

d) Any high voltage supply shall be located as close to the detector as possible.

e) The high voltage supply and all high voltage cabling shall be shielded. The shield may be connected to signal ground or chassis ground but not both.

f) Sharp corners in any high voltage cabling or on grounds near the high voltage lines are not permitted.

g) All encapsulated items shall be x-rayed for voids. If voids are found the item shall be stripped and re-encapsulated.

#### 4.5.2.7. High Voltage Detector

All appropriate precautionary measures delineated and implied in Paragraph 4.5.2.7 shall also apply to the high voltage detector and detector circuitry.

### 4.5.3. Command Requirements

#### 4.5.3.1. General

It should be noted that there are two types of commands. The first is a level discrete type which presents, when sent, an "ON" or "TRUE" condition to the instrument full time; i.e., another command must be issued to turn it off, in which case the "OFF" or "FALSE" condition will be presented to the instrument full time. Each command line is bi-level in that each consists of two stable states. The second type of command is a pulse discrete command where an "ON" or "TRUE", or the complement, an "OFF" or "FALSE" condition is issued in the form of a pulse whose duration is 60 ±5ms. Each command line is separate and unique, but may be redundant within the instrument.

#### 4.5.3.2. Command List (Mod 54, Mod 56, Mod 60)

The spacecraft is providing a total of 39 commands for use by the SBUV/2 distributed as follows: 26 pulse discretes and 13 level discretes. Three of the pulse commands shall be used to initiate separate automatic command sequences defined as "Discrete Sun Enable", "Sweep Sun Enable" and "Wavelength Cal Enable". A command listing is provided in Table 9.3.

High voltage turn on for the photomultiplier tube (pmt) requires the transmission of two commands to the SBUV instruments; these commands are High Voltage On and High Voltage Enable. For all SBUV instruments, except FM 6 and 7, the order of transmission of these commands is not important.

However, for FM 6 and 7, the two high voltage commands just mentioned form a sequence which determines the Range 3 Anode/Cathode telemetry configuration. Sending High Voltage On followed by High Voltage Enable will select the pmt Anode to be telemetered. Reversing this sequence (sending High Voltage Enable followed by High Voltage On ) will select the pmt Cathode data for transmission (see Table 9.3). It is not necessary to turn OFF the High Voltage in order to reconfigure the SBUV FM 7 Anode/Cathode data mode. The pmt Anode/Cathode configuration is transmitted in status word 4, bit 15 (see Table 4.7).

#### 4.5.3.3. Control Functions

This system is not intended to be a complete description of the system logic but merely outlines some of the required logic for the mode commands.

1) Each mode command latches the relay of the other mode commands in the OFF state.

2) Each mode command will start the monochromator drive.

3) If more than one mode command is sent in sequence only the last command will be executed.

4) When any mode command is sent the instrument will complete the mode it is in before starting the new mode.

### 4.5.4. Clock and Synchronization Pulses

#### 4.5.4.1. Clocks

The SBUV/2 shall operate synchronously with reference to the clocks furnished by the spacecraft. The contractor has the use of a 1.248MHz clock and a 1Hz clock. One or both of these clocks shall be used to generate all needed timing.

4.5.4.2. Synchronization Pulses

The TIP will provide the SBUV/2 with a major frame synchronization pulse once every 32 seconds, a 128 second synchronization pulse and a 256 second synchronization pulse. Both the 128 second and 256 second pulses occur within one microsecond of the negative going edge of the major frame pulse (MFP) and the contractor has the use of one or both of them.

4.5.5. Analog Electronics

4.5.5.1. Gain Stability

The signals from the radiometer when viewing a calibration source representing the maximum radiance for the chosen gain setting shall be measured when the instrument is maintained at its nominal orbit operational temperature. The calibrated signal obtained when viewing the same source shall not vary more than one percent/5°C when the instrument temperature is varied over the entire temperature range of 0°C to 30°C (the expected variation in ESM temperature).

4.5.5.2. Detector Gain Stability

It is desired that detector gain shall not change at a rate in excess of 5 percent per year for any photomultiplying tube (PMT) used, and 2 percent per year for any other type of detector. However, the contractor must provide a means to determine actual PMT gain changes in orbit. In this context detector gain shall include the gain of the detector plus preamplifier.

4.5.5.3. Linearity

The nonlinearity of the electronic chains as determined by measurement of system response (at the output of the A/D converter) to a known signal inserted at the first stage amplifier input shall not exceed 0.1 percent of the output signal, at any given instrument temperature in the range 0°C to 30°C. In other words if the system response to a test signal '$S_o$' is '$R_o$', then system response to a test signal of '$nS_o$' must be '$nR_o + 0.001(nR_o - R_o)$; where 'n' is any nonzero, positive number and the test signals can vary from the noise level to saturation.

4.5.5.4. Electronic Calibration

A system for calibrating the linearity of the electronics shall be incorporated in the instrument. An electronic staircase (a predetermined sequence of a minimum of 10 known voltage levels) shall be inserted at the earliest practical stage in the amplifier chain, during which time the detector output will be disconnected. Electronic calibration shall not be a commandable function. The electronic staircase will be inserted automatically according to some predetermined schedule when the instrument is not processing scene data; e.g., during retrace of the monochromator.

4.5.5.5. Dynamic Range (Mod 56, Mod 60)

The analog signal level shall have a low voltage offset sufficient to prevent clipping of minimum signals and an upper limit of 0.25 volts greater than the signal corresponding to the maximum scene radiance.

The analog signal from the detector shall be conditioned into three ranges each being (nominally) 100 times more sensitive than the previous range. Range 1 shall be designated as the most sensitive range. For FM 6 and 7, Range 3 data shall be available from either the photo multiplier tube anode or cathode.

4.5.6. Analog to Digital Electronics

Short circuit protection of all interface circuits shall be provided. The radiometer shall operate within specification except for the shorted output while that output is shorted, and the entire radiometer shall operate within specification after removal of the temporary short.

The converter shall digitize analog signals which vary from zero to the upper limit of the analog signal.

Errors in the multiplexer and the A/D converter due to both static and dynamic (AC) crosstalk shall be 1/2 bit or less. The absolute accuracy of the converter shall be $\pm$ 0.04 percent of full scale at 25°C and shall not decrease below 0.1 percent of full scale at 0°C and 70°C.

4.5.7. Phase Reference Pickup (PRP) and Encoder Signals

Redundancy of component and/or assembly is required for the PRP sensors, if used, and all encoder sensors. Redundancy shall be such that any single failure in PRP sensor or encoder sensor does not degrade performance.

4.5.8. Data System

4.5.8.1. General

The data system for the SBUV/2 shall consist of circuitry needed to output all of the UV radiometric data, temperature and voltage monitoring data, and general status information. All of this information shall be fed out and controlled by the spacecraft TIP. The SBUV/2 data system shall be designed to utilize the TIP digital A, digital B and subcommutated analog telemetry channels and the spacecraft analog temperature telemetry bus as specified below. A complete interface description of the spacecraft telemetry system can be found in the General Instrument Interface Specification.

4.5.8.2. Digital A

The SBUV/2 shall be designed to output all digital instrument data to the TIP digital A data channels. This data shall include all radiometric signals, sync words, instrument temperatures, encoder position and any other information required for utilization of the radiometric data.

4.5.8.2.1. Data Output Requirements

The SBUV/2 shall be provided with a data output capacity of 320 bps and data shall be read out sequentially at the TIP interrogation rate of 8.32 kbps. Each minor frame shall contain the housekeeping data and radiometric output data for one sample in the Sweep Mode. In the Discrete Mode or any lower data rate mode other required telemetry data shall be inserted in those minor frames not needed for radiometric data. In all operating modes other telemetry data as required and electronic calibration data shall be inserted in the TIP data stream during retrace or slew of the monochromator.

4.5.8.2.2. Minor Frame Data Format (Digital A)

Each TIP minor frame contains 100 ms of data, two 16 bit words of which are dedicated to the SBUV/2. The data format for each minor frame corresponding to the various operating modes and status word format is shown in Tables 4.6 to 4.8. All data shall be right justified with the LSB of data the right most bit of the 16 bit word.

4.5.8.3. Digital B

The digital B or bi-level telemetry consists of single bit status monitors used for command verification. The sample rate of each allotted bi-level channel will be once every 3.2 seconds and sufficient channels will be made available for use by the SBUV/2. The status of all instrument commands shall be monitored via digital B.

4.5.8.4. TIP Analog Telemetry

TIP contains several subcommutated frames for sampling low rate analog data for which 8 bit resolution is adequate. The repetition rates are once every 32 seconds, once every 16 seconds, and once per second. In general, temperature monitors should be on the 32 second subcom, and motor currents should be on the 16 second subcom; one second subcom channels are no longer available.

Table 4.6

Data Format for Operating Modes 1, 3, and 4

| MINOR FRAME NUMBER | TIP/SBUV WORD 1 | TIP/SBUV WORD 2 |
|---|---|---|
| 0,10,20...310 | STATUS WORD 1 | RANGE 1 DATA |
| 1,11,21...311 | STATUS WORD 2 | RANGE 2 DATA |
| 2,12,22...312 | DIGITAL A SUB COM (1) | RANGE 3 DATA |
| 3,13,23...313 | MEMORY VERIFY | NOT USED |
| 4,14,24...314 | STATUS WORD 3 | NOT USED |
| 5,15,25...315 | STATUS WORD 4 | NOT USED |
| 6,16,26...316 | GRATING POSITION | NOT USED |
| 7,17,27...317 | CCR DATA | NOT USED |
| 8,18,28...318 | RDCL/GPE (2) | NOT USED |
| 9,19,29...319 | FRAME SYNC CODE | NOT USED |

General Comment:

The basic SBUV/2 data frame (channel) is a 20 word block, the format of which repeats at one second intervals. The instrument data sequence is based upon the 32 second TIP Major Frame, making the data format for all operating modes, except Mode 2, identical.

NOTES: (1) Digital A Sub COM is 16 channels deep.
(2) Radiometric DC level/grating position error; eight bits each.

Table 4.7 (Mod 54, Mod 56, Mod 60)

Status Word Format

| STATUS WORD 1 | Bits | DESCRIPTION | LOGIC STATE 1/0 |
|---|---|---|---|
| | 1 | MASTER POWER ON/OFF | OFF/ON |
| | 2 | DATA FORMAT SWEEP/DISCRETE | SWEEP/DISCRETE |
| | 3-5 | SWEEP MODE MAJOR FRAME COUNT | TRUE/FALSE |
| | 6 | RETRACE | ON/OFF |
| | 7-9 | ECAL STEP NUMBER | TRUE/FALSE |
| | 10-12 | COMMAND SEQUENCE STATE | TRUE/FALSE |
| | 13-14 | RANGE ID LINE 0 | ON/OFF |
| | 15-16 | RANGE ID LINE 1 | ON/OFF |
| STATUS WORD 2 | 1-2 | RANGE ID LINE 2 | ON/OFF |
| | 3-4 | RANGE ID LINE 3 | ON/OFF |
| | 5-6 | RANGE ID LINE 4 | ON/OFF |
| | 7-8 | RANGE ID LINE 5 | ON/OFF |
| | 9-10 | RANGE ID LINE 6 | ON/OFF |
| | 11-12 | RANGE ID LINE 7 | ON/OFF |
| | 13-14 | RANGE ID LINE 8 | ON/OFF |
| | 15-16 | RANGE ID LINE 9 | ON/OFF |
| STATUS WORD 3 | 1 | R1 OVERRANGE/ON-SCALE | OR/OS |
| | 2 | R2 OVERRANGE/ON-SCALE | OR/OS |
| | 3 | R3 OVERRANGE/ON-SCALE | OR/OS |
| | 4 | CCR OVERRANGE/ON-SCALE | OR/OS |
| | 5 | CODE ADDRESS A | TRUE/FALSE |
| | 6 | CODE ADDRESS B | TRUE/FALSE |
| | 7-12 | CODE DATA BITS 1-6 | TRUE/FALSE |
| | 13 | DISCRETE SUN ENABLE | ON/OFF |
| | 14 | SWEEP SUN ENABLE | ON/OFF |
| | 15 | W/L* CAL ENABLE | ON/OFF |
| | 16 | $R_3$ ANODE-CATHODE** | ANODE/CATHODE** |
| STATUS WORD 4 | 1 | DIFFUSER STOW POSITION | STOW/NOT STOWED |
| | 2 | DIFFUSER MONITOR POSITION | MONITOR/NOT MONITOR |
| | 3 | DIFFUSER SUN POSITION | SUN/NOT SUN |
| | 4 | DIFFUSER DECONTAMINATION POS. | DECON./NOT DECON. |
| | 5 | DISCRETE MODE | ON/OFF |
| | 6 | SWEEP MODE | ON/OFF |
| | 7 | DIFFUSER POSITION VALID | VALID/NOT VALID |
| | 8 | DIFFUSER TIMER | TIME OUT/NOT TIME OUT |
| | 9 | CALIB LAMP OPEN | OPEN/NOT OPEN |
| | 10 | CALIB LAMP CLOSED | CLOSED/NOT CLOSED |
| | 11 | CALIB LAMP POSITION VALID | VALID/NOT VALID |
| | 12 | CALIB LAMP TIMER | TIME OUT/NOT TIME OUT |
| | 13 | CALIB MODE | ON/OFF |
| | 14 | POSITION MODE | ON/OFF |
| | 15 | GRATING FIXED/FLEX ($FLEX_1$/$FLEX_2$**) | FIXED/FLEX ($FLEX_1$/$FLEX_2$**) |
| | 16 | GRATING INDEX FOUND | FOUND/NOT FOUND |

*W/L = Wavelength

**For Flight Model 6 and 7 only

Table 4.8

Data Format for Operating Mode 2

| MINOR FRAME NUMBER | TIP/SBUV WORD 1 (1) | TIP/SBUV WORD 2 |
|---|---|---|
| 0,10,20...310 | STATUS WORD 1 | SELECTED RANGE DATA |
| 1,11,21...311 | STATUS WORD 2 | SELECTED RANGE DATA |
| 2,12,22...312 | DIGITAL A SUB COM | SELECTED RANGE DATA |
| 3,13,23...313 | MEMORY VERIFY | SELECTED RANGE DATA |
| 4,14,24...314 | STATUS WORD 3 | SELECTED RANGE DATA |
| 5,15,25...315 | STATUS WORD 4 | SELECTED RANGE DATA |
| 6,16,26...316 | GRATING POSITION | SELECTED RANGE DATA |
| 7,17,27...317 | CCR DATA | SELECTED RANGE DATA |
| 8,18,28...318 | RDCL/GPE | SELECTED RANGE DATA |
| 9,19,29...319 | FRAME SYNC CODE | SELECTED RANGE DATA |

NOTE: (1) Same as all other modes.

The spacecraft provides a separate +28 volt bus to each instrument for monitoring temperatures critical to instrument survival, and which must be available even when the instrument is turned off. This bus is not intended to provide a redundant output for essential telemetry contained in digital A, or for other TIP analog telemetry. As this bus may be turned off during normal spacecraft operation, the instrument must be operational without this telemetry data. A total of 17 analog telemetry channels has been allocated to the SBUV/2. The analog telemetry channels and digital A subcommutated telemetry is given in Table 4.9.

#### 4.5.8.5. Test Points

The contractor shall provide test points for engineering and ground level system checkout as required. All test point interface requirements are given in the GIIS.

### 4.5.9. Temperature Control and Measurement

#### 4.5.9.1. Temperature Control Requirements

All temperature controllers shall be of the continuous, proportional type. Control circuitry shall be well filtered so that its operation will not interfere with any of the other instrument circuitry.

#### 4.5.9.2. Temperature Measurement Requirements

When temperature data is required for interpretation of instrument radiometric data the temperature readout circuitry shall be designed to achieve temperature measurement precision of 0.1°C or better. This information shall be read out as digital A data.

### 4.5.10. EMI/EMC Requirements

The SBUV/2 must pass the EMI and EMC tests called out in Section 3.4.2 of the UIIS.

### 4.5.11. Connector and Cable Requirements

#### 4.5.11.1. Spacecraft Interface Connectors

The contractor shall provide as a minimum separate connectors for the following inputs and outputs:

TABLE 4.9 (Mod 14, Mod 89)

ANALOG AND DIGITAL A SUBCOMMUTATED TELEMETRY

TIP Analog Data

1. SM Baseplate Temp. (1)(2)
2. SM Structure Temp. (2)
3. Depolarizer Housing Temp. (2)
4. HVPS Temp. (2)
5. Diffuser Plate Temp. (1)(3)
6. Chopper Motor Temp. (2)
7. Grating Motor Temp. (2)
8. Diffuser Motor Temp. (2)
9. Cal Lamp Motor Temp. (2)
10. Electrometer Temp. (2)
11. Cal Lamp Power Supply Temp. (2)
12. Diffuser Radiator Temp. (2)
13. ELM Temp. (2)
14. LVPS Temp. (2)
15. Output Grounded
16. Cal Lamp Heater Current
17. 28V Main Power

NOTES: (1) Powered from the 28V switched telemetry bus.
(2) -15 to 45 degrees C.
(3) 0 to 80 degrees C.

Digital A Subcommutated Telemetry

| Channel A (Bits 1-8) | | Channel B (Bits 9-16) | |
|---|---|---|---|
| 1A | Chopper Motor Current | 1B | Spare |
| 2A | Diffuser Motor Current | 2B | Diffuser Plate Temp. |
| 3A | HVPS Volts | 3B | SM Baseplate Temp. |
| 4A | Thermistor Bias (10V ref.) | 4B | 25V Power Volts |
| 5A | Cal Lamp Temp. | 5B | 15V Servo Volts |
| 6A | ECAL Ref Voltage | 6B | -15V Servo Volts |
| 7A | 15V Sensor Volts | 7B | CCR Diode Temp. |
| 8A | -15V Sensor Volts | 8B | SM Differential Temp. Y Axis* |
| 9A | 24V Motor Volts | 9B | SM Differential Temp. Z Axis* |
| 10A | 5V LED Volts | 10B | Differential Ref. Temp. Z Axis |
| 11A | 10V Logic Volts | 11B | Differential Ref. Temp. Y Axis |
| 12A | Cal Lamp Current | 12B | PMT Cathode Temp. |
| 13A | Spare | 13B | Spare |
| 14A | Spare | 14B | Chopper Phase Error |
| 15A | Spare | 15B | Spare |
| 16A | Lamp Motor Current | 16B | Spare |

*± 5 degrees C

(1) One connector for all power inputs and grounds (returns) from the spacecraft.

(2) One connector for all TIP signals; i.e., A415, C415 and D415 pulses, the major frame, 128 second and 256 second sync pulses, and the 1 Hz clock.

(3) A separate connector for the 1.248 MHz clock.

(4) A separate connector for commands, includes interface power and return.

(5) A separate connector for the digital B outputs to TIP.

(6) A separate connector for TIP analog signals.

#### 4.5.11.2. Test Connectors

A separate test connector(s) (female) shall be provided to permit selected signals within the SBUV/2 to be monitored while the unit is under test on the bench or on the spacecraft (for rapid fault isolation). These test points shall be internally buffered so that system performance will not be affected by monitoring; i.e., short circuit protection of test points shall be provided so that the SBUV/2 will survive the short and operate within specification once the short is removed. This connector will not be utilized by the spacecraft and will be covered for flight.

#### 4.5.11.3. Connector Mechanical Requirements

The shells of all external connectors shall be made from non-magnetic material and shall have electrically conductive finishes. Cadmium plating shall not be used. Connector contacts shall be gold plated but silver plating shall not be used beneath the gold. Connectors shall be keyed, have different numbers of pins or be of different types to prevent accidental mismating. On the chassis, male connectors shall be used for power and input signals and female connectors shall be used for output signals. A minimum of ten percent of the total number of contacts on each connector shall be spares (not connected). Each connector shall be clearly marked with its designation and the marking shall contrast with the surface on which it is displayed. Only these connectors on the approved list of the GIIS shall be selected for use on the SBUV/2 interface.

#### 4.5.11.4. Connector Savers

A set of connector savers shall be delivered with each instrument for use during bench testing and through initial phases of spacecraft testing. These connector savers are to be mounted on the instrument and will not be removed until the instrument has successfully completed its initial spacecraft testing, and until the spacecraft is ready for final acceptance testing.

#### 4.5.11.5. Intra-Instrument Cabling

The contractor shall provide all intra-instrument cabling required for operation of the instrument with the Bench Check Unit (BCU). All intra-instrument flight cabling will be provided by the spacecraft contractor, therefore all signal interfaces should be digital. External intra-box cabling, if any, will be provided by the instrument contractor.

#### 4.5.11.6. Patch Cables

Patch cables shall be used and/or installed where possible as soon as flight hardware is assembled and ready for test. These cables are used to limit the number of mate/demate cycles of the unit connectors. Patch cables shall also contain a third connector or have breakout box capability to enable various signals on the cables to be monitored while the instrument is operating. Mates and demates on all flight connectors shall be minimized and, for the external intra-instrument and spacecraft interface connectors, limited to ten each. Each mate and demate will be recorded in the instrument log.

#### 4.5.11.7. Spacecraft Cabling Interface Requirements

The details on all connectors interfacing with the spacecraft are provided in the instrument UIIS.

### 4.6. MECHANICAL REQUIREMENTS

#### 4.6.1. General Mechanical Design Requirements

##### 4.6.1.1. Mechanical Outline and Weight Limits (Mod 89)

The external dimensions of the Sensor Module shall not exceed 21.22x12.26x14.44 inches in the X, Y, and Z directions, respectively, and its target weight shall be 62.5 pounds or less. The ELM shall remain a separate package and will be mounted inside the spacecraft ESM. The size of the ELM shall not exceed 13.03x8.78x12.20 inches in its X, Y, and Z dimensions, respectively, and its target weight shall be 26 pounds or less. The Sensor Module will be mounted externally on the Earth facing panel of the ESM. The total combined weight of both modules plus the thermal blanket is controlling, and this weight shall not exceed 88.5 pounds.

##### 4.6.1.2. Mechanical Safety Factors

The load bearing mechanical components of the instrument shall be designed for strength safety factors of at least two, considering the applicable flight test requirements of this specification. Motors shall have accelerating torques which are a minimum of three times the frictional torque load at the extremes of instrument operating temperature, and this margin must be demonstrated by test.

##### 4.6.1.3. Angular Momentum

The total instantaneous peak angular momentum component along any spacecraft axis shall not exceed 0.00565 newton-meter-second.

##### 4.6.1.4. Natural Resonances

The minimum natural frequency of all structural components or combinations of structural components shall be greater than 100Hz to avoid coupling with the spacecraft structure resonance.

##### 4.6.1.5. Lubrication

The lubricant used for bearings, gears, and other mechanical drivers must be consistent with the required life of the instrument; including time in test and storage as well as in-orbital operation. Oil and grease quantities added to bearings shall be determined by weight to the nearest 0.1mg. The lubrication used shall be based upon demonstrated performance in space of identical or similar type systems.

#### 4.6.1.6. Ball Bearings

Ball bearings shall be ABEC Class 7 or better, unless it can be demonstrated that bearings of lower quality are suitable. Ball and ball groove finishes shall be better than 2 microinch RMS. Soft metal ribbon ball cages shall be avoided. The preferred cage is laminated phenolic (Synthane LLB grade or equivalent) vacuum impregnated with the chosen lubricant. Cleaning, inspection and lubrication of flight bearings shall be performed by an approved organization other than the bearing manufacturer. Draper Labs, GE - Valley Forge, Battelle, Ball - Boulder, NASA - GSFC are approved sources.

#### 4.6.1.7. Cements and Epoxies

The use of cements and epoxies shall be minimized. Only cements and epoxies on the approved materials list (see Section 4.6.7) may be employed. Mechanical retainers shall be provided as backup where cements or epoxies are used for fastening of optical or mechanical components. No cements or epoxies shall be used in the optical transmission path.

#### 4.6.1.8. Screw Fastening

Self locking screws, non-scarring lockwashers, screws with safety wire holes or solithane are to be used to prevent loosening during environmental testing and launch.

#### 4.6.1.9. Center of Gravity

The center of gravity shall be calculated to 0.2 inch for both the SM and ELM, and measured on each flight instrument to 0.2 inch on both modules as part of the instrument acceptance testing.

#### 4.6.1.10. Contacting Metal Surfaces

Metal surfaces which will move in contact with other surfaces, such as bearings, cams, cam followers, guides, etc., shall be hardened by the optimal means available for the metal and service in question. In no case shall bare 300 series stainless steel, bare aluminum or bare magnesium be used in sliding contact with one another. Dissimilar metals in contact shall be passivated to prevent electro-chemical corrosion.

4.6.1.11. Finish

The external finishes applied to the Sensor Module shall satisfy the optical, thermal, and mechanical requirements of the spacecraft and the SBUV/2.

4.6.2. Spacecraft Interface Requirements

4.6.2.1. Mounting

The mounting face of the Sensor Module housing shall be considered part of the baseplate and as such shall include the mounting feet, thermal insulation if required, and any other interface connected subassemblies.

4.6.2.2. Interface Alignment

A method shall be provided for measurement of the alignment of the SBUV/2 optical axis with respect to three external reference surfaces on the instrument base. Provision shall be made to precisely attach alignment mirrors to these surfaces. These mirrors in turn may be used to boresight the SBUV/2 to the spacecraft and must be located to be seen from the nadir view, along the thrust axis and along the velocity vector. The measurement of the optical axis alignment with the mirrors shall have an accuracy of 0.1 degrees or better, and the measurement precision shall be 0.01 degrees. The mirrors can be permanently attached, but if they are removable, measurement repeatability must be 0.005 degrees or better after mirror removal and replacement. The reference axes shall correspond to the spacecraft X, Y and Z axes. Therefore, the instrument mounting plane is the Y-Z plane and the +X axis is nadir. The instrument mounting feet shall have a coplanarity of 0.005 inch and the mounting hole pattern shall be aligned within 0.1 degrees of the instrument Y and Z axes.

4.6.3. Encoder

The monochromator drive position shall be read out with an optical encoder having a minimum angular resolution corresponding to a nominal wavelength shift no greater than 0.1nm. The alignment of the encoder reference pulse to the encoder fine tracks shall be no greater than 2 arcseconds.

4.6.4. Monochromator Drive Assembly

The monochromator drive shall be designed to spectrally scan from 160nm to 400nm in a series of nominally equal steps, each step corresponding to spectral shift no greater than 0.1nm. Each individual step shall be within $\pm$ 25 percent of the average step size, with a repeatability of $\pm$ 1.5 arcseconds. In addition, the monochromator drive assembly shall have the in-orbit capability of changing each Discrete Mode central wavelength to within $\pm$ one-half resolution element of any selected wavelength in the 160nm to 400nm spectral range of the instrument.

#### 4.6.5. Phase Reference Pickup (PRP)

The PRP, if used, shall be designed to permit sufficient mechanical adjustment of the PRP signal phase relative to the scene signal and all components of the PRP subassembly shall be redundant.

#### 4.6.6. Protective Covers

##### 4.6.6.1. Contamination Covers (Mod 14)

The instrument contractor shall provide removable protective cover(s) and/or other contamination protection capable of protecting the Sensor Module from organic molecular and particulate contamination during all phases of spacecraft integration and testing through final closure of the shroud. In the event that certain mounting hardware, or other portions of the contamination protection system, cannot be removed from the instrument without first removing the instrument from the spacecraft this hardware can remain on the instrument for flight, providing it is flight worthy and is included in the instrument's overall allowable weight budget.

a. Spacecraft Mounting--The cover(s) and/or other contamination protection shall protect the Sensor Module, with Lifting Fixture attached, until it is mounted on the spacecraft.

b. Primary I&T Operations--The cover(s) and/or other contamination protection system shall protect the Sensor Module from contamination while it is on the spacecraft or in the spacecraft integration and test area but unmounted. This system shall be purged with clean, dry $GN_2$ capable of maintaining a class 100 environment within the instrument's optical cavity (the cavity will be as clean as the gas used to purge it), and any portion of it that will not fly shall permit visual observation of any moving part which would otherwise be visible if no cover(s) were used. This cover (s) and/or other contamination protection system shall be in place on the Sensor Module at all times after the instrument is mounted on the spacecraft except for those test situations requiring use of another specialized cover(s), including optical alignment, and shall not inhibit operation of the instrument. Two sets of removable items suitable for use in this environment are required for each instrument.

c. Vibration, EMI, and Acoustic Testing--The cover(s) and/or other contamination protection system (except for flyable items) shall permit necessary visual observation when used with the Sensor Module during spacecraft vibration, EMI and acoustic testing. It shall be purgeable but the purge must be safely removable during actual test periods. The cover(s) and/or other contamination protection system must allow unhindered deployment of the diffuser and cal lamp housing, but must not invalidate or inhibit the environmental testing for which its use is required. Should any removable items provided for use in other environments not be usable in this context, one set of unique section (c) removable items is required.

d. Thermal Vacuum-Testing--The cover(s) and/or other contamination protection system shall be used to protect the Sensor Module during spacecraft thermal vacuum testing. It must allow venting of the instrument during chamber pump-down while at the same time it must protect the inside of the Sensor Module from contamination by backstreaming pump oil. It must allow complete operation of the instrument in all its modes, including deployment of the diffuser and cal lamp housing, and must be IR transparent or designed as not to alter the instrument's thermal environment. Should any removable items provided for other uses not be usable or sufficient for use in this context, one set of unique section (d) removable items is required.

e. Launch Site Operations--The cover(s) and/or other contamination protection system shall be used to protect the Sensor Module during shipment to the launch site and during the period of spacecraft testing prior to mating with the AKM, at which time any cover(s) not possessing special antistatic and fire retarding properties will be replaced with those that do, and this cover(s) will remain on the Sensor Module until final encapsulation of the spacecraft. This cover(s) will be the same size and shape as the cover(s) replaces, and two sets are required for each instrument.

4.6.6.2. Flyable Covers

In orbit the diffusing mechanism shall be stowed behind a protective cover when not in use. A cover for the test connector(s) shall also be provided.

4.6.7. Materials

Nonmagnetic materials shall be used whenever possible. The proposed use of any magnetic materials must be approved by the Technical Officer. Cadmium and Zinc shall not be used, and the use of Magnesium will be approved only if it can be clearly and unequivocally demonstrated to be cost effective. Sun shields, if used, shall contribute no more than a 2 db loss at radio frequencies in the range 136MHz to 1700MHz, and shall not be reflective within that range.

4.6.7.1. Corrosion of Metal Parts

Metal parts shall be made from materials inherently corrosion resistant, or shall be processed to resist corrosion. Bare aluminum or bare magnesium shall not be used.

4.6.7.2. Outgassing of Material

Materials shall not outgas, vaporize, or otherwise degenerate in a space environment in a manner and to a degree as to interfere with the operation of the instrument or any other spacecraft component. Each component shall be free from residual contaminants such as corrosion inhibiting oils, greases, dyes, shim stock, and similar debris.

#### 4.6.7.3. Materials Selection

Selection criteria for outgassing shall be a maximum mass loss of 1.0 percent or less and a maximum collected volatile condensable materials of 0.1 percent or less when tested according to ASTM E 595-77 (See Applicable Document 2.1(11)).

#### 4.6.7.4. Materials and Process Listing

The contractor shall maintain up-to-date Materials, Lubrication, and Process Lists for those materials used in the SBUV/2. They will categorize all materials listed as metals, plastics, coatings, miscellaneous, etc., and adequately identify the items by government specification, process, cure cycle type, chemical composition and/or manufacturer. The Listings will also specify the application(s) of each material in the subsystem. The lists will be in the format of GSFC Form 18-59 A, B, C, and D and all information requested therein shall be provided. GSFC forms will be supplied if required.

### 4.6.8. Magnetic Fields

The SBUV/2 shall be designed to minimize the permanent, induced, and transient magnetic field effects. The magnetic field of the instrument shall not exceed 100 gamma at a distance of one meter from the instrument, when operating or not operating.

#### 4.6.8.1. Magnetic Susceptibility

The SBUV/2 shall be designed to minimize its susceptibility to magnetic fields. The instrument must operate within specification in the static and dynamic magnetic field environment of the spacecraft. The general magnetic field environment of the spacecraft is described in the GIIS, and the specific environment expected in the vicinity of the SBUV/2 is described in the UIIS.

### 4.6.9. Decomposition Products

Design provisions shall be provided to avoid any adverse effects from orbit and adjust subsystems combustion products: $H_2$, $N_{25}$ $NH_3$, $H_2O$ $N_2H_4$; the AKM products, the Titan II retro-rocket exhaust products; and the Tiros pyro-mechanism blow by products.

### 4.6.10. Venting

Venting shall be sufficient to allow the instrument to withstand the launch pressure profile and thermal vacuum venting.

4.6.11. Mounting and Handling

Removable lifting fixtures have been provided for mounting the SBUV/2 on the spacecraft when the -Z axis is in a vertical position. Existing handling fixtures shall be used with the instruments at all other times.

4.6.12. Identification Name Plates and Markings

All SBUV/2 hardware shall be marked with the name of the unit, part number, serial number, and connector designations per MIL-STD-130D.

4.6.12.1. Name Plates

All deliverable end items shall be permanently marked with a label of the following form:

| | |
|---|---|
| Instrument: | SBUV/2 |
| Contractor: | Ball Aerospace Systems Division |
| Module: | ELM, SM |
| Serial No. | 001, 002, 003, etc. The EMU/FLT shall be serial No. 001 |

4.6.12.2. Marking of Support Hardware

All support hardware must be marked or tagged to insure against loss and to facilitate its usage. Test cables shall be tagged, numbered, and identified with the instrument hardware. The same applies to test equipment and miscellaneous test and support hardware. Shipping containers will be marked as required in the contract document.

4.6.12.3. Subsystem Shipping Containers

The shipping container shall be a suitable storage container and carrying case for each instrument. The container will be capable of being pressurized with dry nitrogen and will include shock protection, shock recorders, and temperature and humidity recorders. The containers will be designed to protect the instruments (a) in storage and (b) in transit via air freight and truck. Separate shipping containers shall be provided for the SM and the ELM.

4.6.13. Outgassing Heaters

The diffuser shall be fitted with an outgassing heater of sufficient wattage to heat the diffuser to a temperature of 300$^{o}$K to drive off any accumulated contaminants after launch. The power requirements of this heater are not considered to be part of the normal instrument operation and are not included in the orbital average power budget of the SBUV/2 (17 watts).

### 4.6.14. Interface Control Drawings

The contractor shall maintain a separate Electrical and Mechanical interface control drawing for use by the spacecraft contractor. These drawings shall be reproducible and submitted in triplicate when changed.

## 4.7. THERMAL REQUIREMENTS

### 4.7.1. General

This section outlines the thermal design approach and interface requirements necessary to achieve proper thermal control of the instrument. More detailed information is contained in the UIIS.

### 4.7.2. Spacecraft Thermal Interface (Mod 14)

The SBUV/2 will be mounted on the earth facing panel of the spacecraft Equipment Support Module (ESM) but shall be independent of the spacecraft interface. The Sensor Moduleshall be in thermal contact with the ESM external surface through the mounting feet only, and the design shall be such that under operation in the mission mode the instantaneous radiated and conducted heat flow between it and the spacecraft shall not exceed 5 watts.

The ESM panels are constructed of honeycomb faced with 12 mil aluminum sheeting on both sides, total thickness is 1.25 inches. The thermal properties of the panels which are to be used in any thermal analysis are as follows:

| | |
|---|---|
| Lateral Conductance | 0.1 Watt per inch - $^{o}$C. |
| Through Conductance | 0.024 Watt per inch524 - $^{o}$C. |

The lateral conductance refers to heat flow in the panel parallel to the face sheets and includes the face sheets. The through conductance refers to heat flow normal to the face sheets and does not include the conductance of the face sheets.

The external temperature of the ESM may vary between 0 and 30$^{o}$C depending upon the sun angle and state of the spacecraft's thermal control system. Should heater power be required for operation of the SBUV/2 in the mission mode it must be counted as part of the SBUV/2 power budget; it would also be available for instrument operation in the launch mode or standby mode. Total heater power available in any operating mode shall not exceed the total average power budget less the power dissipation in that mode.

### 4.7.3. Thermal Control Requirements

Passive Thermal Control techniques shall be used whenever possible. This may include the use of sun shields, etc., attached to the SBUV/2 housing or to the ESM adjacent to the instrument, providing their use does not impact any other instrument or spacecraft component. The design and location of any proposed sun shield must be forwarded to the Technical Officer in a timely fashion for coordination with the spacecraft contractor. The use of louvers or other active device for thermal control is permissible. In such an event the temperature control electronics (TCE), calibrated TCE sensors, louvers and heaters will be supplied by the instrument contractor.

4.7.4. Environmental Fluxes

4.7.4.1. Orbital Phase (Mod 14)

Because the solar angle* (defined as the angle between the solar vector and orbit normal) varies over a broad range for any spacecraft the earth facing panel of the ESM will often be exposed to solar radiation. The instrument must operate within specification under all solar illumination conditions. In the event of an interface change the spacecraft contractor will provide detailed orbital heat fluxes for use in subsequent analyses.

4.7.4.2. Launch and Orbital Acquisition Phase

During the launch and orbital acquisition phases the instrument will be exposed to launch vehicle shroud heating, aerodynamic heating and sun angles different from those expected during the orbital phase. In addition, there may be a period of time before turn-on when the instrument is fully eclipsed. The instrument must be capable of surviving these conditions.

4.7.5. Design Requirements

4.7.5.1. Nominal Operating Temperature Range

The SBUV/2 shall meet all performance requirements of this specification in the nominal temperature range 0 to 30°C, as measured at the baseplate. This temperature is derived from the operating temperature of the ESM. The thermal design should be adequate to maintain the SBUV/2 within these temperature limits when operating in the mission mode. However, these numbers are not rigid. The contractor can open his nominal temperature operating range if thermal design considerations require it; but, the unit must be calibrated and operate within specification over the entire range.

*See Section 4.7.6 for a complete description of the solar angle.

4.7.5.2. Survivable Temperature Range

The SBUV/2 shall be designed to survive periods in orbit during which the instrument may be off. It must survive the temperature extreme expected under those conditions without degradation or failure. However, it need not perform within specification when instrument temperatures fall outside its nominal operating temperature range.

4.7.5.3. Standby and Launch Phase Mode Heating (Mod 14)

The contractor may provide a heater(s), attached to the instrument to insure instrument survivability or to otherwise maintain the instrument within its temperature design limits. This heater(s) can be used in all operating modes as required provided its power dissipation is included in the instrument's total power budget. The heater(s) may be automatically controlled.

4.7.5.4. Thermal Analysis

The contractor shall be responsible for the thermal design of the instrument for all phases of flight, and shall construct a general thermal model for this purpose. The general thermal model must be validated by instrument test and modified as necessary.

4.7.5.5. Reduced Thermal Model

The contractor shall maintain a reduced thermal model which shall be forwarded to the spacecraft contractor via the Technical Officer in the event a change becomes necessary. The requirements for the reduced thermal model are:

(1) The model shall not contain more than 20 instrument nodes.

(2) The mounting feet and mounting surface adjacent to the spacecraft shall be included as nodes.

(3) Sketches or drawings describing the model shall be provided.

(4) The reduced nodes shall be in tabulated form with the following minimum data provided for each node:

(a) Conductive and radiative couplings.

(b) Power dissipations; a power profile shall be included which contains maximum and minimum powers under all modes of operation.

(c) Thermal capacity.

(d) Heat absorbed by each external node (transient, sun, albedo, and earth IR) versus sun angles and orbit times for at least the ( = $40^\circ$ and $80^\circ$ sun angle orbits.

(e) Surface areas, absorptions, emittances and external radiative couplings for all external nodes.

(f) Temperature profiles assumed for adjacent components shall be provided, if used.

(5) The instrument designer shall validate the reduced thermal model by making comparisons with his general thermal model for at least three transient computer runs. The results of that comparison shall be provided. The mean internal temperatures resulting from both models should agree within $3^{\circ}$ C. The heat transferred to or from the spacecraft should agree within approximately 1/2 watt.

4.7.5.6. Thermal Blankets

The contractor shall be responsible for the design of and shall supply any and all thermal blanketing which may be required, except for the boot blanket over the SM connector bracket, which will be supplied by the spacecraft contractor. All flight blankets shall be baked out for a minimum of 48 hours in vacuum at $80^{\circ}$C prior to shipment to the spacecraft facility.

4.7.6. Description of the Solar (Gamma) Angle (Mod 14)

Because the spacecraft Z axis will be nominally coaligned with the orbit normal, the gamma angle can be defined as the angle between the satellite-to-sun line and the spacecraft Z axis. The angle may vary between zero and 80 degrees, depending on the orbit, and will trace a cone about the Z axis during each orbit. The spacecraft will be in eclipse for a portion of each orbit for all gamma angles greater than 28 degrees, the duration of eclipse increasing with gamma angle. This period of eclipse will occur when the sun is in the third and fourth quadrants (below the Y-Z plane) as seen from the spacecraft.

In general a spacecraft in a morning, descending node orbit and while operating over its design lifetime may encounter gamma angles from zero to 40 degrees, depending upon the orbit, and spacecraft in an afternoon, ascending node orbit may encounter gamma angles from 40 to 80 degrees, depending upon the orbit. The instrument will be flown on afternoon spacecraft only and will be positioned on the spacecraft to optimize diffuser performance at the required gamma angles. As the ATN series of spacecraft does not possess the capability for orbit adjust (maintenance of a fixed equatorial crossing time) extended operational life can result in a decrease in the lowest gamma angle well below 40 degrees for an afternoon spacecraft. The instrument must accommodate a gamma angle range of $80^{\circ}$ - $10^{\circ}$.

## 4.8. CONTAMINATION CONTROL

To minimize particulate contamination, the flight hardware shall continuously be maintained in a clean environment equivalent to class 10,000 as defined in Fed Std 209B. When the instrument is in an area which is not class 10,000, e.g., the spacecraft contractor's integration area, the optics must be protected. Precautions shall be taken such that body oil (fingerprints), facial hair, etc., shall not come in contact with flight hardware. To minimize molecular contamination, items such as Tygon tubing, materials containing plasticizers, etc., shall not be used or stored in the vicinity of flight hardware.

### 4.8.1. Molecular Contamination

A two-way deployable cover (i.e., one that can be opened and closed upon command) shall be provided to protect the critical optical elements of the SBUV/2 from molecular contamination, excessive quantities of which are expected to be deposited on the SBUV/2 during the launch phase of the flight. It is also possible that molecular contamination sufficient to degrade instrument performance will occur in spacecraft thermal vacuum testing, therefore, the cover shall be operable in a 1g field as well as a zero g field. For details see Applicable Document No. 2.1(6).

(Intentionally left blank)

# 5. GROUND SUPPORT EQUIPMENT REQUIREMENTS

## 5.1. GENERAL (Mod 103)

The SBUV/2 Ground Support Equipment (GSE) shall comprise the unique equipment required to operate, test, check and calibrate the SBUV/2.

## 5.2. SYSTEM TEST EQUIPMENT (STE)

### 5.2.1. General (Mod 103)

The System Test Equipment (STE) shall be used to operate the SBUV/2 during all testing at the contractor's plant. It shall provide to the SBUV/2 power, clock, command and telemetry interfaces which are normally furnished by the spacecraft. The STE shall be capable of archiving and displaying with limits testing all instrument data received from the SBUV/2 or STE archive.

### 5.2.2. Requirements (Mod 103)

(1) The STE shall furnish all power, clock frequencies, TIP timing signals and commands required by the SBUV/2. The STE shall be designed to duplicate as closely as possible all interfaces normally supplied by the spacecraft. Test points for monitoring all spacecraft related signals shall be provided.

(2) The contractor shall purchase and design into the STE automatic data processing equipment. The equipment must, at a minimum, be capable of generating self-test programs, command sending and verification programs, limit checks, and a method of archiving all test data. The contractor may use any self-consistent analog or digital storage format for all internal data processing. However, all data which is required to be delivered to either NOAA or GSFC shall be delivered on acceptable storage media (magnetic tape, CD-ROMS, portable drive, etc.) created from the data archiving system that supports the STE. Each file shall contain a header which shall contain all pertinent data such as time of day, test being conducted, instrument status, etc. Data structures created within the STE will be documented in a SER or software user’s manual. Chronological test log shall be maintained at all times whether it is on the SBUV server or special delivered storage media, shall be properly annotated with the date, test data contained thereon, number of files, etc. to facilitate their use.

(3) The contractor is responsible for maintaining the STE including the automatic data system until the end of the program.

(4) The STE shall have the capability of making a hard copy of selected instrument raw data, specially formatted/manipulated instrument data and all other information which is archived or processed by the STE.

(5) The STE shall provide a means of decommutating any word in the SBUV/2 output data stream and displaying the total decimal count and its identification in arabic numerals as a screen product. Digital A subcommutated analog telemetry data shall be displayed in analog form. Digital B status indicators and digital A status bits shall be decommutated in real time and clearly displayed on the STE console.

(6) The STE shall provide an interface with all ancillary test equipment including the standard irradiance sources. All essential data from this external equipment shall be automatically integrated with the instrument data by the automated data system for correlation with instrument radiometric data.

(7) The STE shall provide test points for all significant SBUV/2 and STE voltages and signals required to assess the operational health of each system.

(8) The STE shall have the capability of processing archived data as input in place of instrument live data.

(9) The STE archived data shall be stored on acceptable storage media for the creation of a long term data base.

## 5.3. BENCH CHECK UNIT (BCU)

### 5.3.1. General (Mod 103)

The contractor shall design and produce a Bench Check Unit (BCU). Upon completion of all instrument procurement activities and upon written direction of the Contracting Officer, the BCU shall be delivered to the spacecraft contractor's facility for permanent retention. The BCU will be used to perform functional and operational checks of the SBUV/2 when the instruments are not on the spacecraft. The BCU must have the capability of making detailed functional and electrical tests of the instrument.

### 5.3.2. Requirements

(1) The BCU shall be a functional duplicate of the System Test Equipment (STE).

(2) The contractor is required to deliver all cabling to be used with the BCU upon its delivery to the spacecraft contractor's facility.

(3) The contractor is responsible for maintaining the BCU, including the automated data system and software, until the end of the contract.

## 5.4. VACUUM CHAMBER AND OTHER AMBIENT TEST EQUIPMENT

### 5.4.1. Vacuum Chamber Test Equipment

The chamber test equipment shall consist of a vacuum chamber test fixture, which shall be compatible with the STE and all UV calibration sources. This Vacuum Test Fixture (VTF) shall be used to accommodate the instrument and sources for all tests requiring use of the vacuum chamber.

### 5.4.2. Primary Test Fixture (PTF)

The contractor shall maintain a PTF which shall be used in conjunction with the STE for all system functional checks, electrical checks, ambient performance test and primary calibration, which can be done in the clean room. This fixture will be as identical as possible to the VTF in order to eliminate fixture related changes in the test data.

### 5.4.3. UV Calibration Targets

One set of targets shall be used at the contractor's facility, where it is practical to do so, to provide the baseline radiance and irradiance calibration of the SBUV/2 and to demonstrate its flight worthiness. Where it is not practical to share a UV source or target between the VTF and PTF, a second copy will be procured.

### 5.4.4. Target Control Consoles

The contractor shall maintain one control console for each independent set of targets. The control units shall be designed to drive and control the UV sources, and provide collection and readout capability for all required target telemetry data. These consoles shall have provision to read the target's telemetry into the STE. The contractor is responsible for maintaining all source control consoles until the end of the contract.

### 5.4.5. Cables and Connectors

The spacecraft contractor will provide all cabling required for spacecraft thermal vacuum testing.

### 5.4.6. Contamination Control

Prior to testing of flight hardware, a bake-out shall be conducted with all test equipment, e.g., fixtures, harnessing, etc. A quartz crystal microbalance shall be used and the test concluded when the accretion rate drops to 150 counts per hour or less. Witness mirrors shall be installed in the chamber during the bake-out as well as during thermal vacuum testing of the flight hardware.

## 5.5. ANCILLARY EQUIPMENT

### 5.5.1. Drill Fixtures

The contractor shall maintain the existing ELM drill fixture and use it for drilling the mounting holes in the SBUV/2.

### 5.5.2. Software (Mod 103)

The contractor shall generate and maintain all required computer programs which will be used in the processing and interpretation of the test and calibration data. These shall include, but not necessarily be limited to the following: An instrument calibration program, a data logging program, a limit check program, and any other software required for special data processing, output formatting and storage media generation.

### 5.5.3. Handling Fixtures

The contractor shall use a handling fixture with each SBUV/2 Sensor Module. This fixture must be designed to prevent excessive direct handling of the Sensor Module during assembly, test and shipment operations. The handling fixture shall be shipped with the Sensor Module for use at the spacecraft contractor's facility.

### 5.5.4. Other Equipment and Fixturing

The contractor shall maintain all other facilities and test equipment required for fabrication, subsystem testing, functional testing, and final acceptance testing of the SBUV/2.

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# 6. TEST AND CALIBRATION REQUIREMENTS

## 6.1. GENERAL REQUIREMENTS

The contractor is required to demonstrate by practical test and by instrument calibration that the items produced under the contract meet all the requirements of this specification. He shall, as a minimum, perform all tests and calibrations outlined below.

### 6.1.1. Test and Calibration Plans

The contractor shall maintain an up-to-date instrument test and calibration plan covering the requirements below. This plan must be sufficient to obtain all information needed for demonstrating specification compliance and for full interpretation of the orbital data. The contractor shall include his definition of the pass/fail criteria.

### 6.1.2. Test and Calibration Procedures

The contractor shall maintain and update as required test and calibration procedures which shall be based upon the approved test and calibration plan. All newly generated or modified test procedures shall be submitted to NASA for review and approval before use.

### 6.1.3. Documentation of Test and Calibration Data

The contractor shall organize the results of all system tests into a final presentation data package which shall become a record of all acceptance test data and instrument and subsystem calibration data. These data books are to be a record of all pertinent test and calibration data, including all raw data from which graphs, curves, etc., were prepared and which will be used as an aid in determining the flight worthiness of the instrument. Each section of the data book shall contain functional equations and charts pertinent to the data contained therein, and shall contain all data pertinent to the performance requirements and the final calibration of the instrument and every instrument subsystem as determined from all tests and calibrations performed prior to delivery of the instrument to the Government.

### 6.1.4. Performance Checks

The contractor shall perform an abbreviated functional and performance test of the instrument immediately before and after each of the qualification or acceptance level environmental test specified in this document. In the case of vibration, these tests will be performed after each axis vibration has been completed.

### 6.1.5. Retesting

In the event of a failure during qualification testing or acceptance testing the contractor shall be required to rerun the complete test starting at the beginning of whichever test the failure occurred, unless the retest is shortened upon direction of NASA. The exact nature of retest shall be determined by the Technical Officer.

### 6.1.6. Limits Program (Mod 103)

The contractor shall provide and maintain software to monitor all functions of the SBUV/2 on a real time basis. Certain functions shall be designated as critical and the program will be designed to alarm should a critical fault occur and, then, automatically shut down the instrument if appropriate operator action is not taken. This program shall be designed to verify all operational modes of the SBUV/2 and note any out-of-tolerance items as they occur by changing display color/format and writing the condition to a message file. This program will be used any time the instrument is being operated from the STE.

### 6.1.7. Data Processing Software (Mod 103)

The contractor shall provide and maintain all software required by the various test procedures for processing of instrument data. A software flow diagram or listing shall be submitted as part of each test procedure where appropriate. No system tests shall be started until software required for data processing, as per the approved procedure, has been generated and debugged.

### 6.1.8. Controlled Documents

The Calibration and Test Plan and all calibration and test procedures including software shall be controlled documents. Each shall bear a cover sheet which will indicate all changes made to it after it has been approved and placed under configuration control. Each subsequent change whether originated by the GSFC or the contractor shall be effected by Configuration Change Request procedures.

## 6.2. ENVIRONMENTAL TEST REQUIREMENTS

### 6.2.1. General

The SBUV/2 flight models shall be subjected to the following acceptance level environmental tests. Except where noted the units must meet all specified performance criteria during these tests. The units are to be operated during these tests in a manner simulating actual operation during the various flight stages. The use of any environmental facility other than those at the contractor's own plant requires prior approval in writing from the Technical Officer.

### 6.2.2. Vibration Tests

The SBUV/2 flight units shall be subjected to the following acceptance level vibration tests in each of three orthogonal axes; during these tests the instrument shall be in its launch configuration.

#### 6.2.2.1 Random Vibration (Mod 14)

The SBUV/2 flight units shall be subjected to the following acceptance level vibration tests in each of three orthogonal axes; during these tests the instrument shall be in its launch configuration.

<u>Random Vibration - Both Modules, All Axes</u>

| Frequency Range (Hz) | Power Spectral Density (g524/Hz) | G-RMS | Duration (Min./Axis) |
|---|---|---|---|
| 20-75<br>75-100<br>150 - 500<br>500 - 2000 | 0.005<br>+10dB/Oct.<br>0.05<br>-7dB/Oct. | 5.9 | 1.0 |

#### 6.2.2.2 Load Test (For instruments with primary resonance above 100 Hz) (Mod 14)

In order to meet fracture control requirements, a load test shall be conducted with 12.0g longitudinal and 3.0g lateral loads applied simultaneously (12.4g's) in the ZX and ZY planes (spacecraft coordinates). The test method may be either static load, centrifuge or sine burst (see attached description). Sine burst will usually be the most practical. The approach does require an angle fixture, determined by the longitudinal and lateral test levels. An alternative test is to apply the combined load (12.4g's) in the X, Y, and Z axes, where the test item is mounted on the shaker, as it will be on the spacecraft.

SINE BURST

The sine burst test is used to simulate a static load condition on the test item. The test is performed on a vibration shaker. The frequency used to perform the test is a function of both the dynamic characteristics of the test item and the vibration shaker facility limitations. Because the test is intended to impart a static load to the test item, the test frequency must be below the fundamental resonant frequency of the test item. As a general guideline, the test frequency should be less than one-third the test item resonant frequency to avoid dynamic amplification during the test. The vibration shaker facility limitation is driven by the maximum allowable displacement for the particular shaker. If it is not possible to perform the test using sine burst, then other tests, such as acceleration (centrifuge) or static load, should be examined.

Figure 6-1 shows a typical sine burst waveform. The waveform is sinusoidal with a ramp up to maximum level, several cycles at maximum level, and then a ramp down to zero. Goddard Space Flight Center has performed many sine burst tests. These tests are usually done at or near 20 Hz. The number of cycles at maximum level is usually 6 to 10 cycles. The specification of a sine burst test should contain the following information:

- o Test level = $\pm$ XX g.
- o Test frequency = less than one-third the fundamental resonant frequency of the test item.
- o Test duration = 6 to 10 cycles at maximum level.

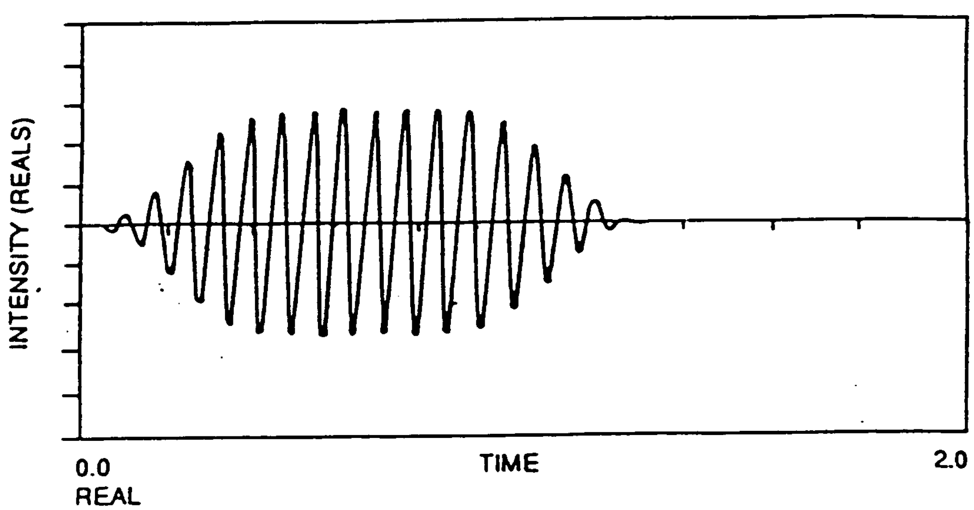


Figure 6.1 Sine Burst (Mod 14)

### 6.2.3. Shock Test (Mod 14)

The SBUV/2 flight units shall be subjected to the acceptance level shock test whose spectrum, pulse, or complex transient, (provided in Figure 6.2) is to be applied along the three major axes of the test items.

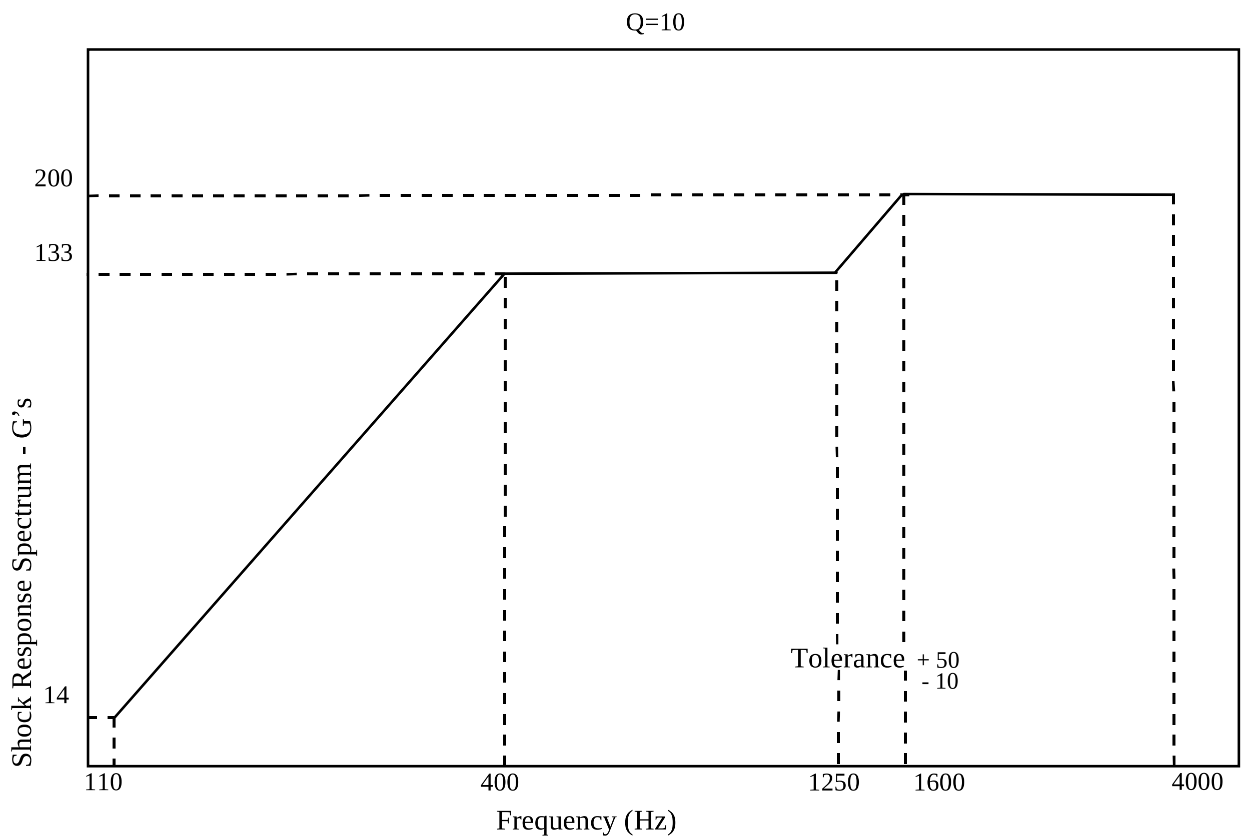


Figure 6.2 Acceptance Level Shock Spectrum (Mod 14)

#### 6.2.4 Launch Phase Pressure Profile (Mod 14)

The instrument design shall be such that, when subjected to the environment shown in Figure 6.3, no adverse conditions will result which may affect instrument performance. An actual test is required if analysis does not indicate sufficient margin of safety.

#### 6.2.5 Acoustic Test Requirements

The spacecraft with its payload, as part of its environmental testing sequence, shall be exposed to the acoustic levels shown in Table 6.1. During launch, a similar environment is expected inside the shroud.

The specified instrument random vibration levels are based upon the acoustic levels, which are coupled with and conducted through the spacecraft structure and, finally, mechanically transmitted to the instruments. Since the random levels envelope the transmitted acoustic levels, there is no requirement for acoustic testing of the instruments.

The contractor should review his instrument for large area/low mass components which would be exposed to and could be affected by direct acoustic energy. Such instrument components may require an acoustic test to assure adequate performance.

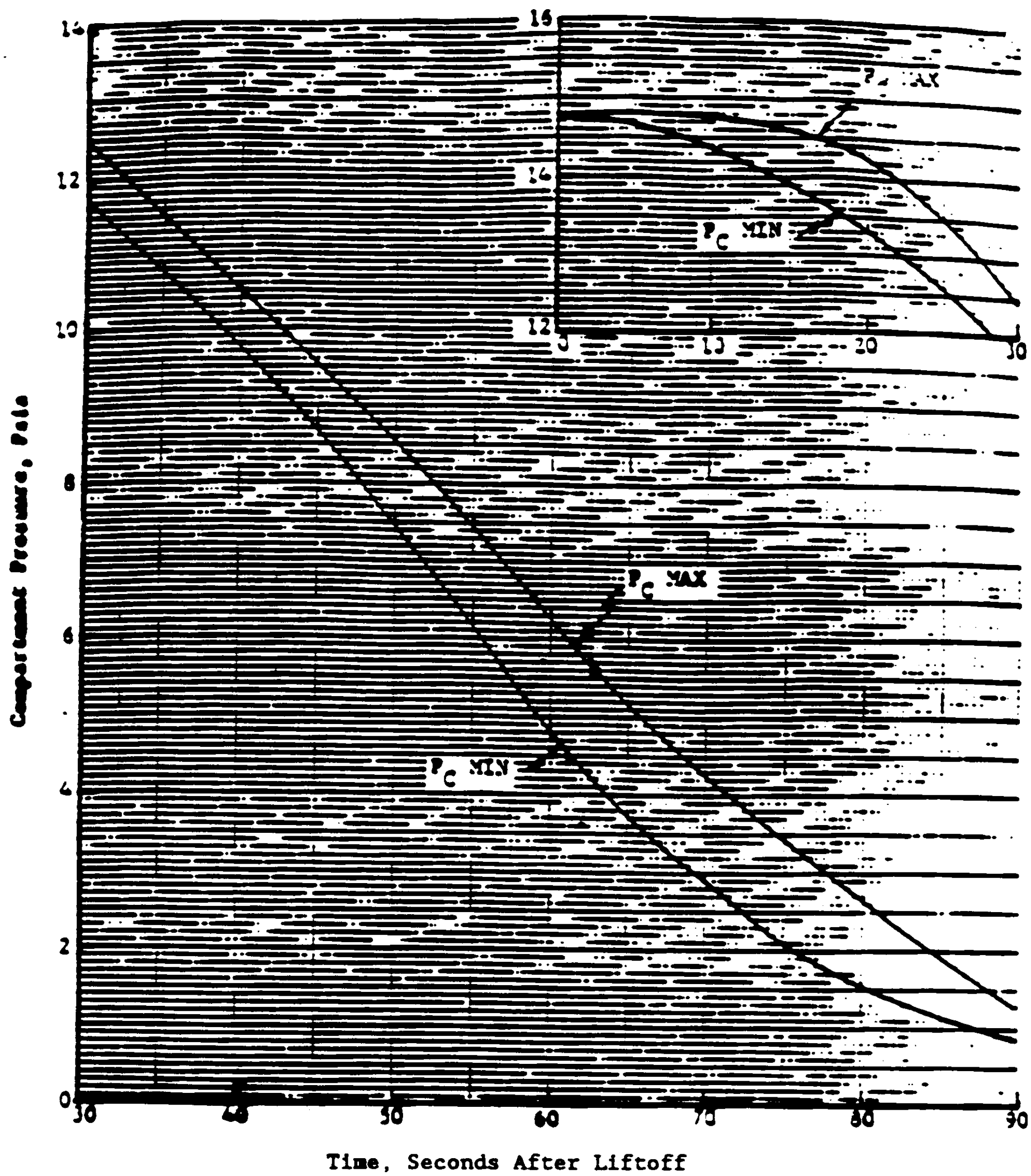


Figure 6.3 S/C Compartment Pressure Time History (Mod 14)

Table 6.1

Acoustic Test Criteria - Internal Levels

| 1/3 Octave Band Center Frequency (Hz) | 1/3 Octave Band Sound Pressure Level (dB) | |
|---|---|---|
| | Qualification | Acceptance |
| 40 | 120.5 | 117.5 |
| 50 | 123 | 120 |
| 63 | 125 | 122 |
| 80 | 126.5 | 123.5 |
| 100 | 128.2 | 125.2 |
| 125 | 130 | 127 |
| 160 | 131.5 | 128.5 |
| 200 | 133 | 130 |
| 250 | 133.8 | 130.8 |
| 315 | 134.5 | 131.5 |
| 400 | 134.75 | 131.75 |
| 500 | 134 | 131 |
| 630 | 133 | 130 |
| 800 | 130.5 | 127.5 |
| 1000 | 128 | 125 |
| 1250 | 125.5 | 122.5 |
| 1600 | 122.5 | 119.5 |
| 2000 | 119 | 116 |
| 2500 | 116 | 113 |
| 3150 | 113 | 110 |
| 4000 | 109 | 106 |
| 5000 | 106 | 103 |
| 6300 | 102 | 99 |
| 8000 | 98 | 99 |
| 10000 | 95 | 92 |
| OA | 142.5 | 139.5 |

The test duration will be 1.0 minute.

### 6.2.6. Thermal Vacuum Acceptance Test Requirements (Mod 14)

The SBUV/2 flight units shall be subjected to a thermal vacuum test in which the pressure is $1x10^{-5}$ torr or less and the test temperature profile is as shown in Figure 6.4. The unit will be in the launch phase mode for pump down and in the mission mode for all other phases of this test. During temperature transitions the rate of change in temperature shall

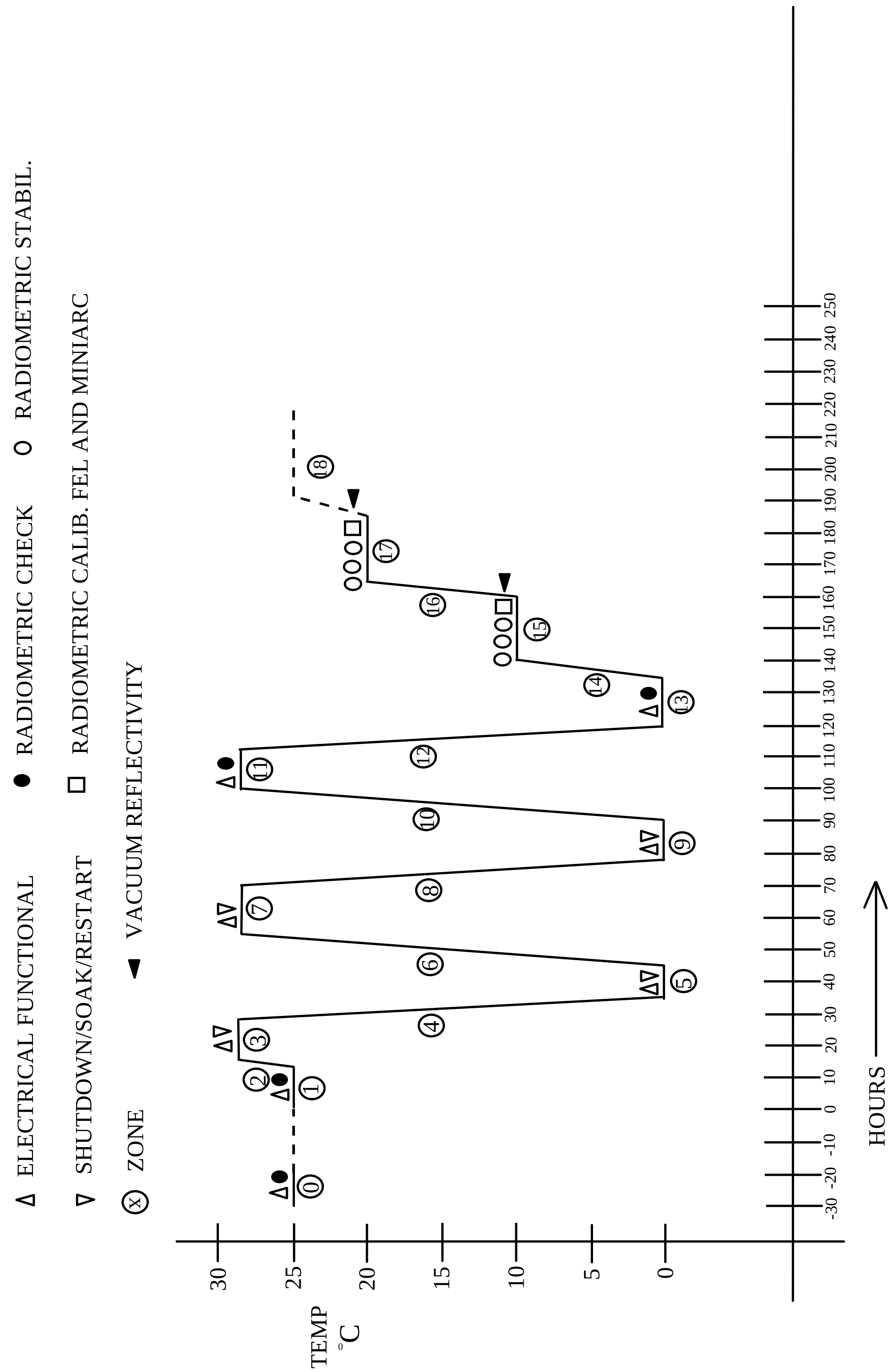


Figure 6.4  Thermal Vacuum Acceptance Test Profile.
See Table 6.2 for an outline of the test
sequence. (Mod 14)

not exceed 10°C per hour or be less than 5°C per hour. The instrument is required to operate within specification over this temperature range.

Thermocouples or thermistors shall be attached to the unit in sufficient numbers to measure the maximum and minimum structural temperatures as well as those critical temperatures required for calibration purposes and survival. The control point of the test for conformance to the specification shall be based on the thermal instrumentation of the baseplate. This instrumentation shall not invalidate the true nature of the thermal environment being measured.

6.2.6.1. Shutdown and Restart Tests

System shutdown and restart in orbit shall be simulated. At the extreme thermal vacuum temperature plateaus the instrument shall be shut down and temperature allowed to stabilize before the instrument is restarted. Once all temperatures are stabilized the unit will be restarted and warmup time measured. Care must be taken to insure that the instrument does not go below the minimum allowed temperature during temperature stabilization at the low temperature plateau.

6.2.6.2. Vacuum Environment

For all thermal vacuum testing the vacuum environment shall be oil free, i.e., oil diffusion pumps shall not be used.

6.2.7 Systems Level Temperature Test (Mod 9)

The contractor shall perform a system level temperature test of the instrument depolarizer over the instruments required operating temperature range. This test shall be conducted in a manner to allow visual observation of the depolarizer throughout the test so that any fringing or other evidence of a potential thermally induced failure can be observed and documented. An optical separation of one or more surfaces (as evidenced by a complete fringe pattern distributed over the visible surface of the depolarizer, or by a sudden signal decrease) at any temperature within the range of 0°C - 30°C shall constitute an instrument failure.

| Zone | Time* | Activity |
|---|---|---|
| 0 | - | Pre Pumpdown Electrical Functional and Radiometric Check |
| l | 8 | Post Pumpdown Electrical Functional and Radiometric Check |
| 2 | 4 | Orbit Simulation |
| 3 | 12 | Electrical Functional and Shutdown/Restart |
| 4 | 10 | Orbit Simulation |
| 5 | 12 | Electrical Functional and Shutdown/Restart |
| 6 | 10 | Orbit Simulation |
| 7 | 12 | Electrical Functional and Shutdown/Restart |
| 8 | 10 | Orbit Simulation |
| 9 | 12 | Electrical Functional and Shutdown/Restart |
| 10 | 10 | Orbit Simulation |
| 11 | 12 | Electrical Functional and Radiometric Check |
| 12 | 10 | Orbit Simulation |
| 13 | 12 | Electrical Functional and Radiometric Check |
| 14 | 4 | Temp Change and Stabilize |
| 15 | 24 | Calibration/Vacuum |
| 16 | 4 | Temp Change and Stabilize |
| 17 | 24 | Calibration/Vacuum |
| 18 | <u>24</u> | Power Down and Bleed up Chamber |
| Total | 214 | |

*Hours

Table 6.2 Thermal Vacuum Test Sequence (Mod 14)

## 6.3. SYSTEM PERFORMANCE TEST REQUIREMENTS

### 6.3.1. Specification Compliance Tests

The contractor shall perform all tests necessary to demonstrate that all quantitative instrument performance requirements of this specification have been met. This includes all requirements placed on subsystems and components by this specification, directly or indirectly.

### 6.3.2. Bench Tests

The STE or BCU shall be used by the contractor to operate the instrument during the system performance tests off site and whenever a limited quick-look check or trouble-shooting is required. It will be used at the spacecraft contractor's plant for incoming acceptance tests and for any other system evaluation tests which might be required.

### 6.3.3. General Electrical Performance Test

The contractor shall use a short, but comprehensive, electrical performance test which shall form the basis of the bench check test. This test shall be used in conjunction with other tests as a check of instrument performance before and after certain environmental tests. This test shall include use of breakout boxes to measure critical electrical parameters which would not normally be monitored by the spacecraft. It is intended that the availability of the automated data processing equipment shall not be a prerequisite.

### 6.3.4. General Optical Performance Test

The contractor shall use a short, but comprehensive, optical performance test to be used in conjunction with the general electrical performance test, to demonstrate that the instrument is in compliance with the optical requirements. This test will be performed before and after any system environmental test which might change instrument performance, and after the instrument has been shipped or subjected to any non-standard environment.

### 6.3.5. Ground Support Equipment Tests

The contractor shall perform tests as required to demonstrate that all GSE is functioning properly and within specification.

## 6.4. SYSTEM CALIBRATION TEST REQUIREMENTS

### 6.4.1. General

The determination of instrument response versus scene radiance and solar irradiance of each spectral band must be a comprehensive test of the system design and performance. This test must be capable of producing the information needed for processing the data gathered in orbit. The calibration shall be planned to 1) demonstrate subsystem performance, and 2) provide the data from which the instruments calibration coefficients, can be determined.

It is also required that all temperature and voltage monitors be calibrated. Equations and/or coefficient data tables for converting instrument output to a voltage or temperature, including all raw data, are to be provided as part of the Alignment and Calibration Data Book.

### 6.4.2. Calibration of System Response (Mod 9)

The contractor shall calibrate and test the instrument in all its operating modes to determine its response to a known stimulus and to determine all significant corrections to this response as the instrument is operated over its required temperature range of 0°C - 30°C, and over its expected orbital dynamic range. Where source limitations preclude absolute calibration over the total dynamic range the relative instrument response shall be monitored and normal instrument function demonstrated. The calibration environment for the instrument shall simulate the expected orbital thermal environment, using heaters as sources, and the instrument shall be tested with its full complement of shields and thermal insulation.

#### 6.4.2.1. Sources

For instrument radiometric calibration the contractor shall use a NBS standard source(s) of spectral irradiance appropriate to the wavelength range in question. All calibrations are to be done in air when possible, but response reproducibility checks will be made in vacuum. For scene radiance measurements an external near lambertian diffuser shall be used while solar irradiance measurements are to be made using the instrument's diffuser. During calibration all steps required to correct the instrument's response for changes in the external diffuser, if any, are to be taken.

#### 6.4.2.2. Radiometric Calibration Plateaus (Mod 14)

Radiometric response calibration measurements utilizing the argon arc, quartz iodide (QI) lamp or any other standard source shall be made at the following instrument baseplate temperatures for both the Discrete and Sweep Modes of operation: +10°C, and +20°C, providing the instrument baseplate follows the external ESM temperature. If the instrument temperature is controlled to some value 'To' calibration must be performed at To and To + 10°C only. The stability of the baseline calibration shall be established in all channels at each temperature plateau prior to leaving that plateau.

6.4.2.3. Radiometric Calibration

The instrument shall be calibrated while operating in the normal mission modes, i.e., in the Discrete Mode and in the Sweep Mode. A significant number of data samples shall be taken at each Discrete Mode step or at each Sweep Mode wavelength to ensure a statistically meaningful determination of the standard deviation and/or standard error. In the Discrete Mode a minimum of 50 data samples is recommended, while a minimum of 20 data samples is recommended for the Sweep Mode.

6.4.2.4. Linearity Calibration

The contractor shall provide a calibration of system linearity. A minimum 20 point calibration, equally spaced over the instrument dynamic range, along with extra data points in the R2 to R3 overlap region, is required.

6.4.2.5. Diffuser Calibration (Mod 14)

The contractor shall provide a goniometric calibration of the instrument with the on-board diffuser deployed to the position used for viewing the sun in orbit. This calibration shall encompass a gamma angle range of 10 - 80 degrees and shall provide a goniometric map over the spectral range of 250 - 400nm. As part of the goniometric calibration the contractor shall measure the angle between the on-board diffuser normal and the instrument's X, Y, and Z axes. In addition, a baseline vacuum calibration of the relative spectral reflexivity shall be provided.

6.4.2.6. Gain vs Wavelength Calibration

The contractor shall provide a gain vs wavelength calibration of the instrument. This gain between R2 and R3 is to be measured in 20 nm increments over the spectral range 185 nm to 408 nm, and at the 12 discrete wavelengths. All measurements are to be taken at the R3 signal levels; at 400 counts and at 700 counts.

6.4.2.7. Instrument Calibration Software

The contractor shall provide and maintain all realtime and off-line software necessary to generate a complete radiance and irradiance calibration of the instrument in both the Sweeps and Discrete modes of operation. The final product shall be a determination of the calibration coefficients for the twelve Discrete mode wavelengths. In the sweep mode the radiance constraints shall be determined over the spectral range 200 to 400 nm, and the irradiance constraints shall be determined over the range 160 to 400 nm.

6.4.2.8. Deleted (Mod 103)

6.4.3. Calibration Fixture

The contractor shall maintain a basic test fixture which shall be used for all possible instrument tests including calibration. Two copies of this basic fixture shall be used, one for ambient test and calibration and the other for vacuum testing and calibration. These two fixtures shall be as identical as the separate environments will permit and shall have provision for mounting the QI lamps, argon miniarc and/or other irradiance sources simultaneously and shall contain collimating optics between each source and the test (external) and instrument diffuser plates. At no time shall a calibration or repeatability check be conducted with one source or some other component of the fixture removed. The fixture configuration must remain invariant in order to eliminate fixture dependent differences in instrument response.

6.4.4. Responsibility

The calibration of the SBUV/2 shall be the sole responsibility of the instrument contractor. Acceptance of the instrument shall be predicated upon its successful calibration. Therefore, the contractor must take appropriate action, from the outset, to insure that instrument calibration has been properly planned, defined, understood, approved, and documented prior to the start of final acceptance testing.

6.4.5. Calibration of Temperature and Voltage Monitors

6.4.5.1. Temperature Measuring Circuits

The contractor shall use thermistors that have a 0.5 percent interchangeability and resistors having a tolerance of 0.1 percent in all temperature measuring circuits. For those temperatures which are to be read out in digital A, the measuring circuits shall be calibrated in terms of output in counts versus temperature in degrees C. Those temperature monitoring circuits to be read out as spacecraft analog data shall be calibrated in terms of volts versus temperature. The temperature range covered by each thermistor shall be +30°C about the expected nominal value.

6.4.5.2. Voltage Monitors

The contractor shall provide calibration curves of the instrument internal voltage monitoring circuitry in terms of counts versus volts.

## 6.5. SPECIAL DATA REQUIREMENTS

### 6.5.1. History Data Storage (Mod 103)

Whenever the instrument is operated from the STE or BCU the contractor shall generate a long term database, containing all SBUV/2 output data plus all ancillary data necessary for the use of the instrument data. This database will be archived on acceptable storage media.

### 6.5.2. Deliverable Storage Media (Mod 103)

The contractor shall provide copies of selected portions of the long term data base on acceptable storage media. The selected data shall be identified by date, test particulars and start and stop times of the record.

(Intentionally left blank)

# 7. PROGRAM SUPPORT REQUIREMENTS

## 7.1. PROGRAM REVIEWS

### 7.1.1. Preshipment Reviews

A Preshipment Review (PSR) will be held upon completion of the acceptance testing and calibration of the flight units, and before delivery of each unit. Items that shall be considered as a minimum in this review are qualification or acceptance test results, malfunction reports, and certification of performance. Delivery of the protoflight unit or flight units shall not occur until after the resolution of all action items resulting from the PSR unless otherwise directed in writing by the Technical Officer.

#### 7.1.1.1. Preshipment Review Data Package

The contractor shall submit to the Technical Officer twenty-five copies of the data package in time for their distribution at GSFC at least ten working days prior to each review. The detail of this information contained therein shall be sufficient to demonstrate that the instrument has met all performance and acceptance test requirements and is acceptable for flight.

### 7.1.2. Program Management Reviews

The contractor shall conduct a quarterly program review for the Metsat Project Manager. These reviews shall take approximately one day and shall be held at the contractor's facility.

(Intentionally left blank)

## 7.2. CONFIGURATION MANAGEMENT

### 7.2.1. Program and Plan

The contractor shall establish and maintain a configuration management program based on the requirements of MIL-STD-480 and this specification which encompasses flight and ground hardware and software. A configuration management plan, defining the program, shall address the following requirements: (1) A brief description of the contractor's change control system with a flow chart, (2) an orderly and well defined method of assuring approved changes are, in fact, incorporated into the hardware and/or software, (3) quality assurance participation in the change control system, (4) GSFC review and approval of contractor proposed changes, and (5) configuration management deliverable documentation listed in Table 7.3. Subsequent revision and/or updating of the approved plan shall be submitted for GSFC approval prior to implementation.

### 7.2.2. Classification of Changes

Proposed changes which require either review or approval by the GSFC Tiros Project Configuration Control Board (CCB) shall be classified as follows:

(1) Class I change -- Requires GSFC Approval

Any change which impacts the GSFC Tiros Project's technical performance requirements, technical interface, or cost and schedule requirements is defined as a Class I change.

(2) Class II change -- Requires GSFC Review

A change shall be classified Class II when it does not fall within the definition of a Class I change. Class II changes do not require GSFC concurrence prior to implementation. Examples of a Class II change are: A change in documentation only (e.g., correction of errors, addition of clarifying notes or views); or change in hardware which does not affect any factor listed under Class I changes.

Class I changes originated by the contractor shall be documented on a Tiros Configuration Change Request, GSFC 480-39, and submitted to the GSFC Tiros Project CCB for approval prior to implementation. Class II changes originated by the contractor and approved by the contractor's CCB shall be submitted on the contractor's internal change forms for GSFC review.

### 7.2.3. Configuration Management Documentation

Configuration management program reports shall be submitted by the contractor as part of the Weekly Status Reports described in Section 8.1. Documentation shall be submitted in accordance with Table 7.1. These shall be subject to action by GSFC as indicated.

Table 7.1

CONFIGURATION MANAGEMENT DOCUMENTATION

| | Document Title | Copies and Delivery Requirements | GSFC Action |
|---|---|---|---|
| 1. | Configuration Management Plan | 3 Copies When Updated | Approval |
| 2. | Configured Article List (List of Equipment Content by Assembly (SBUV/2) and Module Serial Numbers) | 1 Copy With Hardware | Review-On Site |
| 3. | Drawing Tree | 2 Copies as Updated | Information |
| 4. | Configuration Changes | | |
| | a. Class I (GSFC Form 480-39) | 2 Copies as Generated | Approval |
| | b. Class II | 2 Copies as Generated | Review |
| 5. | Configuration Management Reporting | Part of Weekly Status Report | Information |
| 6. | Indentured Drawing List (List of All Program Specifications, Drawings, Tests, Procedures, etc.) | 3 Copies as Updated | Information |
| 7. | Any Program Document | 1 Copy Upon Request | Information |

## 7.3. INSTRUMENT STORAGE AND TESTING REQUIREMENTS

### 7.3.1. Instrument Storage

Following completion of an instrument the contractor shall store that instrument until it is needed at the spacecraft facility for integration on a waiting spacecraft. Authorization for shipping will be given via Technical Direction from the Technical Officer.

#### 7.3.1.1. Storage Requirements

The contractor shall provide for and store all instruments accepted by the Government but not yet needed for spacecraft integration. Instruments shall be stored in a class 10,000 clean room under a purged Lexan cover, or stored in their shipping containers which can be kept in bonded flight stores in an appropriate temperature and humidity controlled environment. The contractor shall provide this support for the storage of all delivered instruments, from this and previous contracts, until the end of the contract, at which time all residual flight instruments shall be shipped to the spacecraft facility.

#### 7.3.1.2. Shipping Requirements

The contractor shall prepare and ship an instrument upon receipt of written Technical Direction. This Technical Direction shall be provided at least 30 days prior to the required shipping date. The expected instrument need dates are provided in Table 9.1 for NOAA-I through NOAA-M.

### 7.3.2. Storage Testing (Mod 9)

The contractor shall perform the required storage tests on all instruments in storage. These tests shall be conducted every twelve (12) months on each instrument so long as it is in storage and shall include but not necessarily be limited to a PMT conditioning test, a normal bench test, a diffuser albedo characterization test and a response repeatability test; the latter to be conducted one time only during the pre-ship storage test. This PMT conditioning test shall incorporate all recommendations of the tube vendor and shall be treated as an Acceptance Test for review and approval purposes.

This storage test shall be repeated prior to the shipment of any instrument to the spacecraft facility providing the normal twelve month test has not been performed within 60 days of shipment. In addition, spare PMT's held in flight stores shall be conditioned on the bench every twelve months in accordance with vendor recommendations.

(Intentionally left blank)

## 7.4. FIELD SUPPORT AND OTHER GENERAL SUPPORT

### 7.4.1. Basic Requirements

The contractor shall provide the qualified personnel for the additional on-site support required for all instruments. This additional support will include but not necessarily be limited to the following specific tasks.

#### 7.4.1.1. Post Delivery Bench Testing

The contractor shall prepare and ship the STE and other test equipment to the spacecraft contractor's facility along with the delivery of each instrument, and provide the personnel to perform a post delivery bench test. This test will be performed as soon after delivery as possible and before the instrument is integrated on a waiting spacecraft or placed in storage. Following the bench test the contractor shall arrange for and ship the STE and other test equipment back to his facility. At final instrument delivery the BCU will be shipped in place of the STE and retained by the spacecraft contractor, along with any other test equipment as might be directed by the Contracting Officer. This requirement applies to instruments developed under this contract as well as to instruments held in storage from previous contracts.

#### 7.4.1.2. WSMC Operations

The contractor shall support all SBUV/2 launches which occur during the life of the contract. This support shall include removal of the optical cavity contamination mirrors and replacement with mirror blanks prior to spacecraft encapsulation at WSMC, redress of thermal blankets and final inspection. In addition the contractor shall perform a contamination analysis on the mirrors and report the results prior to spacecraft launch. Three launches are anticipated. The anticipated spacecraft launch dates are provided in Table 9.2.

#### 7.4.1.3. Deleted (Mod 2)

7.4.2. Additional Integration and Launch Support

7.4.2.1. Spacecraft Integration and Test Support

The contractor shall provide any additional on-site support at the spacecraft facility as may be required during the life of the contract. This may include support during specific instrument/spacecraft tests, troubleshooting of test anomalies, and minor rework or repair.

7.4.2.2. Launch Support

7.4.2.2.1. WSMC Operations

The contractor shall provide any additional on-site support at WSMC as may be required during launch operations.

7.4.2.2.2. Post Launch Support and Data Analysis

The contractor shall provide any post launch on-site support as may be required at the Spacecraft Operations Control Center, Suitland, Maryland. This support may be required during the Activation and Evaluation phase, during specialized instruments testing and may include on-site evaluation of anomalous behavior or orbital failures.

7.4.2.3. Authorization for Additional Support

Authorization for additional support as defined in paragraph 7.4.2 will be implemented on a task order basis in accordance with Section C of the contract.

7.4.3. Major Troubleshooting and Failure Analysis

7.4.3.1. Troubleshooting of Instrument Failures

In the event of a pre-launch failure or serious anomaly the contractor shall provide the personnel and facilities necessary to perform system level troubleshooting and/or minor repair(s) as may be required. This support may include on-site evaluation and test at the spacecraft facility or WSMC as well as further troubleshooting and/or simulation at the contractor's facility.

7.4.3.2. Failure Analysis

The contractor shall provide any analytical support that may be required by the activities defined in paragraph 7.4.3.1. This analysis shall include a recommendation(s) for resolving the failure as well as a proposal for performing the required repair(s) and system retest.

7.4.3.3. Logistics Support

In the event an instrument must be returned to the contractor's facility for troubleshooting and/or repair, the contractor shall arrange for and provide the shipping required.

7.4.3.4. Authorization for Additional Support

Authorization for additional support as defined in paragraph 7.4.3 will be implemented on a task order basis in accordance with Section C of the contract.

7.4.4. General Analytical Support

7.4.4.1. General Analysis

The contractor shall provide any analysis which may be required by spacecraft modification or other mission changes which might impact the SBUV/2; e.g., the incorporation of new instruments onto the spacecraft, gamma angle changes, antennae relocation, etc.

7.4.4.2. Failure Analysis

The contractor shall provide any analysis as may be required as a result of orbital failure(s) or other anomalous behavior requiring resolution. This may include troubleshooting and/or simulation using residual hardware.

7.4.4.3. In-orbit Performance Evaluation

The contractor shall provide support to NASA and NOAA for the purpose of analysis and evaluation of each instrument's in-orbit radiometric performance, as may be required, to help provide the necessary instrument characterization and the corrections which must be applied to the raw data for use in the retrieval algorithm.

#### 7.4.4.4. Advanced Mission Studies

The contractor shall provide the analytical support required to determine the impact of and/or instrument modifications which may be necessary to accommodate a major change, such as a change in spacecraft or an enhancement of mission performance requirements.

#### 7.4.4.5. Authorization for Additional Support

Authorization for additional support as defined in paragraph 7.4.4 will be implemented on a task order basis in accordance with Section C of the contract.

### 7.4.5. Prelaunch Instrument Recalibration

The contractor may be required to provide a recalibration of any instrument whose scheduled launch date is more than 2 years following its previous calibration. In the event the instrument in question has been delivered to the spacecraft facility it will be necessary to return the instrument to the contractor's facility for recalibration.

#### 7.4.5.1. Shipping and Other Test Requirements

The contractor shall arrange for and provide all necessary transportation for the tasks outlined below, and shall perform all test activities indicated.

a) Ship the necessary test equipment to the spacecraft facility for bench testing and perform a bench test.

b) Return the instrument and test equipment to his facility and perform a post arrival bench test.

c) Perform the necessary recalibration.

d) Ship the instrument and test equipment to the spacecraft facility and perform a post delivery bench test.

e) Return the test equipment to his facility.

#### 7.4.5.2. Recalibration of Instruments Held in Storage

If the instrument has been in storage for 2 years or more it may need recalibrating just prior to delivery for integration on a waiting spacecraft.

7.4.5.3. Recalibration Requirements

The instrument recalibration shall include but not necessarily be limited to the following:

a) A check of the wavelength calibration.

b) A check of the gain vs. wavelength calibration.

c) A check of the FOV size and uniformity.

d) A check of the diffuser albedo characterization.

e) A repeat of the ambient calibration including the normal incidence radiance calibration and the PTF radiance and irradiance calibration.

f) A reprocessing of all radiometric calibration data.

Should any of the calibrations checked show any significant changes, it may be necessary to repeat the entire calibration.

7.4.5.4. Authorization for Recalibration

Authorization for any task defined in paragraph 7.4.5 will be implemented on a task order basis in accordance with Section C of the contract.

7.4.6. Shuttle SBUV Support

The contractor shall provide additional support to the SSBUV project as may be required. It is anticipated that the spectral reflectance of the in flight calibration mirrors will need to be mapped before and after each flight. Additional analytical support or measurements and on site support at the GSFC may be required as well.

Authorization for additional SSBUV support will be defined and implemented on a task order basis in accordance with Section C of the contract.

## 7.5. MAINTENANCE OF GROUND SUPPORT EQUIPMENT (GSE)

### 7.5.1. Retained Equipment

The contractor shall provide the personnel and facilities necessary to maintain all retained GSE until the end of the contract. Retained GSE is that equipment to be delivered to the GSFC at the close of the contract and includes the STE, source control consoles, all test fixturing, etc.

## 8. DOCUMENTATION REQUIREMENTS

Copies of all documentation herein described, plus cover letter, shall be submitted to the Technical Officer.

### 8.1. MANAGEMENT DOCUMENTS

#### 8.1.1. Project Organization Chart

The contractor shall provide with his proposal a detailed project organization chart showing the assignment of key personnel such as the project manager, system engineer, mechanical, optical and electrical engineer, R&QA personnel, etc. This chart will be maintained and 3 copies submitted as updated throughout the contract.

#### 8.1.2. Project Plan

The contractor shall submit a preliminary project plan for GSFC review with his proposal, and 3 copies of a final plan prior to contract award, for GSFC approval. The project plan shall include a work breakdown structure (WBS), a work flow plan, a cumulative expenditure curve and a man hour allocation and cost chart. The contractor shall prepare a work breakdown structure through level V as defined in "Handbook for Preparation and implementation of Work Breakdown Structure NHB 5610.1." After contract award, the cumulative expenditure curve, man hour allocation and cost chart through level IV of the WBS, shall be updated and submitted monthly; one copy is required. The monthly man hour allocation and cost chart shall show the past month as well as the cumulative total.

#### 8.1.3. Weekly Status Reports

Each week the contractor shall telefax to the Technical Officer a written report indicating the status of the contract as of close of business the preceding Friday, including a summary of progress made. This report shall include, but not necessarily be limited to the following, as required:

(1) Technical progress, including significant accomplishments and milestones reached.

(2) Problems encountered and proposed corrective action.

(3) Any actual or anticipated slip in schedule.

(4) A monthly summary listing by number and title of all newly released drawings, specifications, procedures and technical reports.

(5) Monthly review and/or closeout of previously reported problems and corrective action taken.

(6) Monthly summary of new malfunction reports and status of previously issued reports.

(7) Monthly update of critical item status, i.e., a listing of critical parts not yet received including expected delivery dates and actual need dates.

(8) A monthly parts shortage summary and schedule impact.

(9) A listing of man-hours worked on the program and cost expenditure summary for the reporting period.

(10) Any other reports or summaries called out in Tables 7.1 of this specification.

Note: This weekly report is intended to be timely and should summarize the above topics only as changes or problems occur.

8.1.4. Schedule Reports

8.1.4.1. Detailed Schedules

The schedule for the procurement phase shall be detailed by major items or components or definable subassembly, such as chopper motor or the optical elements for the grating subassembly, etc., and by class. This latter element shall be subdivided into standard electrical components, integrated circuits, etc. Once orders have been placed the schedule will be updated to show the date all parts or components were ordered and the promised delivery dates. The schedule for the fabrication phase shall be detailed to the mechanical subassembly level and to the electronic board level, and shall show the expected start and completion dates, as well as substantive in-process milestones.

The schedule for the integration and test phase shall begin at the start of instrument buildup at the subassembly level and shall detail all start and completion dates. For the test phase the schedule shall be detailed to show the expected start and completion dates of the final tests on individual assemblies, major tests associated with system integration such as alignment, and the individual all up systems test, such as the initial performance test, the field of view test, the vibration test, etc.

These detailed instrument schedules shall be updated and submitted quarterly with the new forecast, but will be submitted as generated; PERT charts are preferred, and one copy is required. After start of instrument fabrication the schedules shall be updated verbally on a weekly basis or in the Weekly Status report.

## 8.2. ENGINEERING SUPPORT DOCUMENTATION

### 8.2.1. Definitions

The following documents, which do not necessarily comprise a complete listing, are classified as engineering support documents:

(1) All technical reports and analyses.

(2) Internal technical memoranda.

(3) Specifications.

(4) Drawings; which shall include layout drawings, detailed piece part drawings, assembly drawings, system level drawings, interface drawings, wiring diagrams, schematics, logic diagrams, cable routing drawings and assembly procedures.

(5) Engineering change notices and CCR documents.

(6) Weight, power and system error budgets.

(7) Parts and materials listings.

(8) Engineering reports and design review documentation.

### 8.2.2. Requirements

#### 8.2.2.1. Engineering Analysis Reports

The contractor shall provide technical analysis reports as may be required in support of all aspects of the procurement cycle, fabrication, system integration, test and calibration of the flight units. It is expected that, during the course of these activities, the contractor will study, analyze and make adjustments and decisions regarding numerous technical subjects relative thereto but not heretofore specifically called out. These additional analyses and studies shall each be documented as System Engineering Reports (SER). Each SER shall be typed or legibly written and may contain hand drawn sketches to preserve informality and timeliness.

#### 8.2.2.2. Weight and Power Budget

The contractor shall maintain a current weight budget listing the weight of each subassembly and the total weight of each module. In addition, the contractor shall maintain a current power budget listing the power of each major module and the combined totals for the various modes of operation.

### 8.2.3. Documentation Delivery

(1) Twenty-five copies of each preshipment review data package as specified in paragraph 7.1.1.1.

(2) Two copies of each new SER; two copies of any other or subsequent design analyses and/or technical reports; two copies of each new contractor generated internal technical memorandum pertaining to the SBUV/2; three copies of each new engineering change notice; three copies of each new or revised specification, and two copies of the revised weight and power budgets, shall be delivered as generated.

(3) Three copies of each new drawing released, as well as revisions of drawings previously released, as generated.

(4) Three reproducible copies each of the revised mechanical and electrical, interface control drawings as generated.

### 8.2.4. Drawing Specifications

All drawings shall be made in accordance with MIL-D-1000. All flight hardware drawings shall be level 2 drawings.

### 8.2.5. Drawing Books

The contractor shall continue to maintain six copies of the SBUV/2 Drawing Book, two of which shall be delivered to the Technical Officer and the remaining four retained by the contractor for his usage. These books shall be looseleaf type, "B" sized and contain all major drawings, schematics and diagrams of the protoflight SBUV/2 and the GSE (STE and BCU). They shall be maintained up-to-date in the event of revisions. The purpose of the book will be to provide key engineering personnel with a "portable drawing file" for use during the integration, test and calibration of each flight unit.

### 8.2.6. UIIS Documentation

The contractor shall provide, as available or as specified in the UIIS, all documentation and other data identified in the UIIS as TBS-NASA and TBS-Vendor data.

## 8.3. TEST AND CALIBRATION DOCUMENTATION

### 8.3.1. Test Procedures

#### 8.3.1.1. Qualification and Acceptance Test Procedures

The contractor shall furnish and maintain a detailed test plan for the testing required in Section 6.0.

The contractor shall prepare provide and maintain, under configuration control, detailed test procedures based upon this approved test plan.

These test procedures shall include, as a minimum, the following information:

(1) A brief description of the tests.

(2) A block diagram of the instrument and the test equipment.

(3) A description and location of special monitors.

(4) A step-by-step procedure for conducting the test.

(5) Data sheets with the required values to be measured and room for recording the measured data.

Revised or updated versions of these test procedures shall be submitted to the Technical Officer for approval prior to their use, and no acceptance testing shall proceed until the Technical Officer has given approval. The Technical Officer shall have thirty days to respond to the first submission of a new test procedure. Three copies are required.

A complete description and location of all environmental test facilities proposed for use under this program shall be included in the test plan for review and approval by NASA.

#### 8.3.1.2. Bench Test Procedures (Mod 14)

The contractor shall maintain a comprehensive test procedure for checking the instrument on the bench at the spacecraft facility. In the event of an update or revision, three copies shall be submitted to the Technical Officer for approval.

8.3.1.3. GSE Test Procedures

The contractor shall maintain test procedures for all ground support equipment to be used for instrument testing. The contractor shall submit revisions or updates to the Technical Officer for approval; three copies are required.

8.3.2. Test Reports

8.3.2.1. Component and Subassembly Test Reports

The contractor shall provide, as available, one copy of any test report supplied by the vendor of any component or subassembly which was manufactured to a performance specification generated by the contractor, e.g., motors and PMT's are instrument components for which a test report must be supplied.

8.3.2.2. Engineering Test Reports

The contractor shall provide one copy, as available, of any test data or report which might be generated to prove a design concept or might otherwise be termed an engineering test.

8.3.2.3. Qualification and Final Acceptance Test Reports

The contractor shall organize the results of all tests into summaries which will be incorporated into a final presentation data package which shall be submitted as part of the PSR data package.

8.3.3. Specification Compliance and Calibration Data Book

All performance specification compliance and calibration data shall be incorporated into a 'Specification Compliance and Calibration Data Book', 30 copies of which are to be delivered within 3 months of delivery of each flight unit. This 'Specification Compliance and Calibration Data Book' shall contain all information necessary for use of the data as received from the spacecraft in orbit. As a minimum the book shall contain the FOV plots of each channel, all alignment data, a summary listing of the required performance data and the actual measured data, the telemetry algorithms and coefficients or the calibration curves for the analog and digital A telemetry, and the coefficients of the best fit radiometric calibration curves generated from the radiometric calibration data. These books are intended to stand alone and must contain enough information to permit interpretation of the orbital data: This does not include the algorithms for producing ozone profiles or determining total ozone, or other operational data products.

## 8.4. GSE INSTRUCTION MANUALS

The contractor shall deliver 10 copies of the following GSE instruction manuals when revised or updated.

### 8.4.1. Instruction Manuals for the Automated Test Equipment (Mod 14)

The contractor shall maintain an instruction manual for all automated test equipment which shall contain a complete and detailed description of the capabilities, operation, and use of that equipment. It shall include a complete set of drawings, logic diagrams, schematics, and any photographs which might prove useful in describing the equipment.

The manual shall be sufficiently complete to allow a qualified technician to instruct himself in the calibration, check-out, trouble-shooting, and repair procedures of the equipment without prior experience with the unit. The check-out procedure called out in paragraph 8.3.1.3 shall be included as an appendix to this manual.

### 8.4.2. Instruction Manuals for Calibration Sources

The contractor shall maintain an instruction manual for all calibration sources and source control units. The manual shall provide all information necessary for installation, operation, calibration and maintenance of each source and of the source controls, including data read-out equipment.

### 8.4.3. Manual Format and Delivery Schedule

The manuals shall be submitted to NASA for review in accordance with the schedule given in paragraphs 8.3.1.2 and 8.3.1.3. Any format is suitable provided all drawings are included as composite numbered pages (reduced in size if necessary) and any associated test procedure is presented in the spacecraft contractor's format.

## 8.5. INSTRUMENT LOG BOOK

An instrument log book shall be maintained at the contractor's facility which shall contain a chronological record of all instrument activity beginning at completion of system integration and continuing up to instrument delivery. This log will be a permanent record of all events pertinent to the unit including all planned test activity, all engineering test activity which might be required because of anomalous operation, all malfunction report activity, the total instrument operating time, and the tape/file numbers of the recorded data for each event using the tape notation.

This record shall be kept current at all times and shall be available for review at any time by any authorized NASA or NOAA representative. A separate log book will be kept for each flight unit.

## 8.6. TECHNICAL DESCRIPTION DOCUMENT

The contractor shall maintain a Technical Description Document which shall be self-contained in that a reader not familiar with the instrument can obtain a reasonably complete understanding of the instrument and its operation operation without recourse to other documents or drawings. The document shall contain a logical description of the SBUV/2 and its operation, instrument instrument block diagrams, logic and signal flow diagrams, schematics where appropriate, optical diagrams, top level assembly drawings and a summary of performance requirements and characteristics. In addition, summaries of significant differences among the flight instruments, including those procured under previous contracts, shall be provided and identified in a separate section of the document. Fifty copies of this document or inserts or appendices are to be delivered when revised or issued.

## 8.7. DOCUMENT DELIVERY SCHEDULES

Specific documentation delivery requirements are provided in Attachment C of the contract.

## GLOSSARY OF ABBREVIATIONS AND ACRONYMS (Mod 56)

| | |
|---|---|
| BPI | Bits per Inch |
| BCU | Bench Check Unit |
| CCB | Configuration Control Board |
| CCR | Cloud Cover Radiometer |
| CDR | Critical Design Review |
| CMOS | Complementary/Metal Oxide Semiconductor |
| ELM | Electronics and Logic Module |
| EM or EMU | Engineering Model (Unit) |
| ESM | Equipment Support Module |
| FOV | Field of View |
| GFE | Government Furnished Equipment |
| GIIS | General Instrument Interface Specification |
| GSE | Ground Support Equipment |
| GSFC | Goddard Space Flight Center |
| IFOV | Instantaneous Field of View |
| MFP | Major Frame Pulse |
| NBS | National Bureau of Standards |
| NOAA | National Oceanic and Atmospheric Administration |
| PDR | Preliminary Design Review |
| PRP | Phase Reference Pickup |
| PLB | Pulse Load Bus |
| PMT | Photomultiplying Tube |
| PROM | Programmable Read Only Memory |
| PSR | Preshipment Review |

| | |
|---|---|
| PTF | Primary Test Fixture |
| QI | Quartz-Iodide |
| R & QA | Reliability & Quality Assurance |
| RAM | Random Access Memory |
| SER | System Engineering Report |
| SM | Sensor Module |
| STE | System Test Equipment |
| TCE | Temperature Control Electronics |
| TIP | TIROS Information Processor |
| T/V | Thermal Vacuum |
| UIIS | Unique Instrument Interface Specification |
| VTF | Vacuum Test Fixture |
| WBS | Work Breakdown Structure |
| WSMC | Western Space and Missile Center |

Table 9.1 Deleted (Mod 14)

Table 9.2 Deleted (Mod 14)

Table 9.3 (Mod 54, Mod 56)

SBUV/2 COMMAND LIST

| # | Command Name |
|---|---|
| 1 | Instrument Power ON/Lamp OFF/High Voltage OFF/High Voltage Disable/ System Reset |
| 2 | Instrument Power OFF |
| 3 | Grating Mode 1 (Discrete) |
| 4 | Grating Mode 2 (Sweep) |
| 5 | Grating Mode 3 (Wavelength Cal) |
| 6 | Grating Mode 4 (Position) |
| 7 | High Voltage ON |
| 8 | Motor Power ON |
| 9 | Motor Power OFF |
| 10 | Lamp Enable and ON |
| 11 | Lamp Disable |
| 12 | Lamp Assembly Open |
| 13 | Lamp Assembly Close |
| 14 | High Voltage Enable |
| 15 | Diffuser Position 1 (Stow) |
| 16 | Diffuser Position 2 (Monitor) |
| 17 | Diffuser Position 3 (Sun) |
| 18 | Diffuser Position 4 (Decontaminate) |
| 19 | Chopper Encoder Sensor-Primary/Backup |
| 20 | Grating Encoder Sensor-Primary/Backup |
| 21 | Diffuser Position Sensor-Primary/Backup |
| 22 | Lamp Position Sensor Primary/Backup |
| 23 | Grating Drive Memory, FIXED/FLEX ($FLEX_1$/$FLEX_2$*) |
| 24 | Code Strobe |
| 25 | Code Address A |
| 26 | Code Address B |
| 27 | Code Data Bit 1 |
| 28 | Code Data Bit 2 |
| 29 | Code Data Bit 3 |
| 30 | Code Data Bit 4 |
| 31 | Code Data Bit 5 |
| 32 | Code Data Bit 6 |
| 33 | Baseplate or Cal Lamp Heater ON |
| 34 | Diffuser Heater ON |
| 35 | Heaters OFF |
| 36 | Not Used (Spare, at instrument only) |
| 37 | Discrete Sun Enable |
| 38 | Sweep Sun Enable |
| 39 | Wavelength Calibration Enable |

*For FM 7 only.

# APPENDIX A
# WAIVERS AND DEVIATIONS

| Deviation/ Waiver No. | CCR No. | CCR Approved Date | Section/ Effectivity | Description |
|---|---|---|---|---|
| SBUV-W-030 | 1121 | 07/07/92 | 4.3.2, 4.3.3.2, 4.3.2.1, 4.3.2.2, 4.3.3.3 (FM-6 S/N 007) | Several aspects of the instrument field-of-view, as measured per procedures 68042 and 68027, are slightly out of specification. The following were measured (see waiver table 1):<br>Sect # — Measured Value<br>4.3.2 — 0.16° max out of square<br>4.3.2 — 0.3 max difference<br>4.3.3.2 — Y-axis 0.21° max; Z-axis 0.20° max<br>4.3.2.1 — (Mono) 21.54% max; (CCR) 7.30% max (from 280 nm)<br>4.3.3.2 — Y-axis 0.21° max<br>4.3.2.2 — 1.7% (Most probably is really better than 1%. Test results limited by signal level.)<br>4.3.3.3 — Monochrometer in Y-axis is 0.07° |
| SBUV-W-031 | 1121<br><br>1154 | 07/07/92<br><br>10/12/93 | 4.5.8.4, Table 4.9 (FM-6 S/N 007)<br><br>4.5.8.4, Table 4.9 (FM-5 S/N 006) | The “out of limits” on the DCR and MCR lines are caused by noise transients and are not caused by excess motor current. They are random in nature and have never repeated on the next data sample. Each occurrence is a singular event. The noise transient has occurred about once every 24 hours of test operation. |
| SBUV-W-032 | 1121 | 07/07/92 | 4.4.3.5, 4.7.5.1 (FM-6 S/N 007) | Sweep mode grating positions are sometimes shifted four positions at temperatures over 30°. The anomaly occurred in backup encoders only and only when the sensor module had a slight nonuniform temperature during the t/v test. In clean room oven tests, the grating performed satisfactorily in tests up to 36°C. Grating position is required to meet the wavelength accuracy of para. 4.4.3.5 and operate between 0°C and 30°C per para. 4.7.5.1. |

| Deviation/ Waiver No. | CCR No. | CCR Approved Date | Section/ Effectivity | Description |
|---|---|---|---|---|
| SBUV-W-033 | 1121 | 07/07/92 | 4.5.8.4, Table 4.7 (FM-6 S/N 007) | The cal lamp door failed to close when commanded three times in one day during an electrical functional test. This failure never occurred before or after this one day on either FM6 or FM5. A noise transient on the door closed circuit resets the cal lamp door electronics to the off state. The door has completed the close operation on receipt of a second command every time. ARC welding was being performed outside of the clean room during the test. |
| SBUV-W-034 | 1155 | 05/29/93 | 4.3.2, 4.3.3.2, 4.3.2.1, 4.3.2.2 (FM-5 S/N 006) | Several aspects of the instrument field-of-view, as measured per procedures 68042 and 68027, are slightly out of specification. The following were measured (see waiver table 1):<br>Sect # — Measured Value<br>4.3.2 — 0.16° max difference<br>4.3.3.2 — Y-axis 0.43° max<br>Z-axis 0.19° max<br>4.3.2.1 — (CCR) 26.1% max<br>4.3.3.2 — Y-axis -0.21° max<br>4.3.3.2 — Y-axis 0.22°<br>Z-axis 0.16°<br>4.3.2.2 — 1.3 (Most probably is really better than 1%. Test results limited by signal level.) |

| Deviation/ Waiver No. | CCR No. | CCR Approved Date | Section/ Effectivity | Description |
|---|---|---|---|---|
| SBUV-W-040 | 1308 | 04/14/95 | 4.3.2,<br>4.3.2.1,<br>4.3.3.2<br>(FM-3 S/N 004) | Several aspects of the instrument field-of-view, as measured per procedures 68042 and 68027, are slightly out of specification. The following were measured (see waiver table 1):<br>Sect # — Measured Value<br>4.3.2 — 0.16° max difference<br>4.3.2.1 — Y-axis, 8.10%<br>Z-axis, 8.28%<br>4.3.3.2 — Y-axis, -0.20° max<br>4.3.3.2 — Y-axis -0.16°<br>Z-axis 0.13°<br>4.3.2 — 0.24° max out of square |
| SBUV-W-042 | 1394 | 04/30/96 | 4.3.2,<br>4.3.2.1,<br>4.3.3.2,<br>(FM3 S/N 004) | Several aspects of the instrument field-of-view, as measured per procedures 68042 and 68027, are slightly out of specification. The following were measured (see waiver table 1:<br>Sect # — Measured Value<br>4.3.2 — 0.13° max difference<br>4.3.2.1 — Y-axis, 5.28%<br>4.3.3.2 — Y-axis -0.17° max<br>4.3.3.2 — Y-axis -0.14°<br>4.3.2 — 0.23° max out of square |
| SBUV-W-043 | 1452 | 06/30/97 | 4.3.2,<br>4.3.3.2,<br>4.3.2.1,<br>4.3.3.3<br>(FM7 S/N 008) | Several aspects of the instrument field-of-view, as measured per procedures 68042 and 68027, are slightly out of specification. The following were measured (see waiver table 1):<br>Sect # — Measured Value<br>4.3.2 — -0.37° max difference<br>4.3.3.2 — Y-axis -0.20° max<br>4.3.2.1 — -5.30% max Vertical<br>4.3.3.2 — Y-axis -0.19° max<br>4.3.3.2 — Y-axis -0.18° max<br>4.3.2.1 — 23.80% max<br>4.3.2 — 0.22° max out of square<br>4.3.3.3 — Monochromator in Y-axis is 0.07° |

| Deviation/ Waiver No. | CCR No. | CCR Approved Date | Section/ Effectivity | Description |
|---|---|---|---|---|
| SBUV-W-046 | 1483 | 07/02/97 | 4.6.1.7 (FM3 S/N 004, FM6 S/N 007, FM7 S/N 008) | The new Cloud Cover Radiometer filter from Optical Corporation of America is bonded with epoxy in the optical path. Para. 4.6.1.7 of this specification requires that no epoxies be in the optical path. (Note: This waiver was originally submitted as SBUV-W-042.) |
| SBUV-W-047 | 1611 | 05/07/99 | FM7 S/N 008 | The SBUV FM7s measured SNR at 252.0 nm in the discrete mode is 33.16 (should be a minimum of 35), and in the sweep mode is 9.73 (should be a minimum of 10). |
| SBUV-W-049 | 1764 | 09/29/00 | FM8 | Signal to noise is 98.9, should be minimum of 100 at wavelength 312.5. |
| SBUV-W-050 | 1765 | 9/29/00 | FM8 | Microphonic noise test. |
| SBUV-W-048B | 1831 | 06/21/01 | FM8 | Waiver to Field of View, Flight 8, s/n 009. FOV size and reference to the Cloud Cover Radiometer. |
| SBUV-W-048 | 1763 | 09/29/00 | FM8 | FOV size and reference to the Cloud Cover Radiometer. The specifications are extremely tight and difficult to measure. Locating the center of the 11 degree field-of-view to within 0.1 degree is difficult because of the nonideal shape of the field-of-view. Field nonuniformity measurements are also affected by the shape of the field of view. The CCR out-of-field measurements are affected by the extremely low signal level resulting from the standard source and the narrow bandpass of the filters. These out-of-spec conditions are similar to those experienced on previous SBUV instruments of the same design. |
| NA | 1769 | 11/14/00 | FM07 | Calibration between 160 and 200 nm was not performed on FM-7 S/N 07 after the solar diffuser angle was changed. The contract modification authorizing BATC to up-grade FM-6 to the configuration of FM-7 did not require BATC to repeat the radiometric calibration in vacuum. The intention was to do this calibration at a later date. At this point the time and cost does not appear to be worth the additional effort. |
| | | | | |